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THE MYCENAEAN PALACE AT NIPPUR.*

By CLARENCE S. FISHER.

THE attention of students of the Mycenaean period, during the last few years, has been centered in the islands of the Mediterranean, where the excavations at Knossos and other sites in Crete have thrown new and important light on that age. So certainly has the sphere of Mycenaean influence appeared to be confined to the Mediterranean and its borders, that its sudden extension to the center of ancient Babylonia comes as an almost impossible revelation. Yet that is just what is meant by the discovery at Nippur, by previous expeditions to that site, of numerous votive steles, figurines, and other objects bearing the characteristics of the Mycenaean age. Now, in addition to all these, we have completely opened up a palace which has an arrangement of courts, halls, and passages exactly similar to that at Tiryns, and comparing favorably with it in size. At present this palace is the only one of the kind uncovered, but the further excavation of the mound in its immediate vicinity is sure to disclose others of the same type. It is impossible that a solitary example of a Greek house should have been erected in a foreign land, where all the customs and systems of building were contrary to the life suggested by the plan; and, taken in connection with the objects found all over the rest of the site, we must conclude that the building formed a part of a settlement on the ruins of the older Babylonian city. The object of the present paper is to give briefly the position and characteristics of this palace and the reasons for assigning it to what I feel is its true place in architectural history.

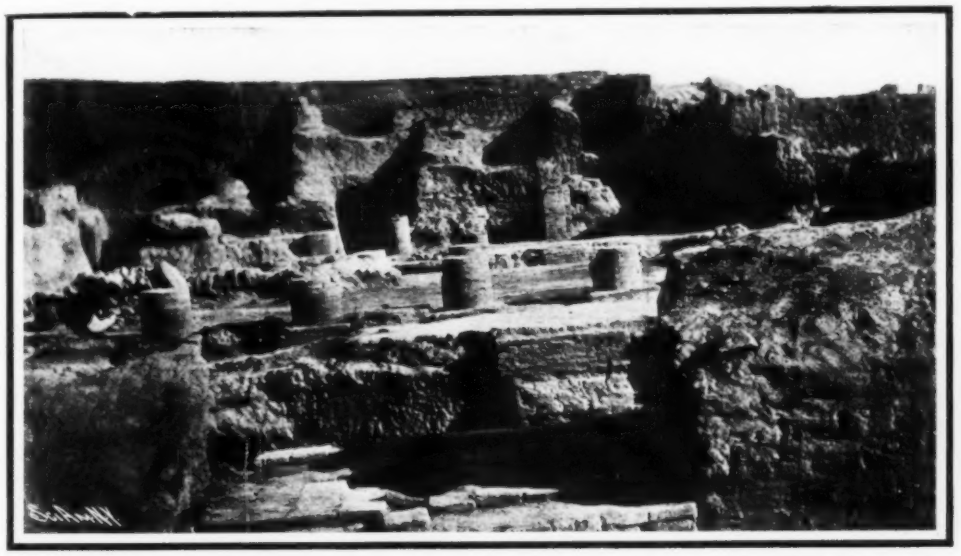


FIG. 4.—VIEW, LOOKING NORTHWEST, THROUGH DOOR OF THE MEGARON ACROSS THE GREAT COURT.

There were at the end of the history of Nippur three periods succeeding each other comparatively swiftly, and covering a space of about seven to eight hundred years. The site during this time was occupied continuously, as we may infer from the slow accumulation of débris, which here on the summit of the mound would not be allowed to fill up the streets to the degree it would in the earlier periods of the city, when the level was still horizontal. Then the inhabitants had to leave the rubbish of their daily life lying in the corners and in the streets, but in the later times it was carried to some unoccupied edge of the mound, and dumped in a common rubbish heap.

Preceding this was the period when the site was not occupied by dwellings, but given up entirely to the disposal of the dead. Just how long this lasted we cannot say, but from the oldest of the burials it would appear to be not earlier than the Greek conquest in 330 B. C. We must, then, account for the great accumulation of débris under which the palace lies buried by a still longer period of time, during which the mounds of Nippur were abandoned entirely.

The walls in the western corner of the palace still have a height of 9 to 10 feet, in almost perfect preservation. This condition would not be possible if the building had not lain a long while in ruins and was slowly covered up by its own débris. We should find the upper portions of the walls torn down, the whole of them leveled off for the walls of the new building to rest upon, and the old materials reused for building purposes, just as we find it to be the case in other parts of Nippur, where the destruction of one building was succeeded immediately by another occupancy. The other corners of the building are not so well preserved, however, and the explanation of this I have been fortunate enough to find in the structure of the walls still *in situ*. From the time that the building was first uncovered it has been accepted as a fact that the palace was destroyed by fire. The crude clay of the walls was baked red, the plastering had become exceedingly friable as a result of fire, and in several of the rooms there were traces of burnt grain. This view of the case was accepted fully by me as the correct one until the complete uncovering of the rooms in the

* Abstracted from American Jour. of Archæology.

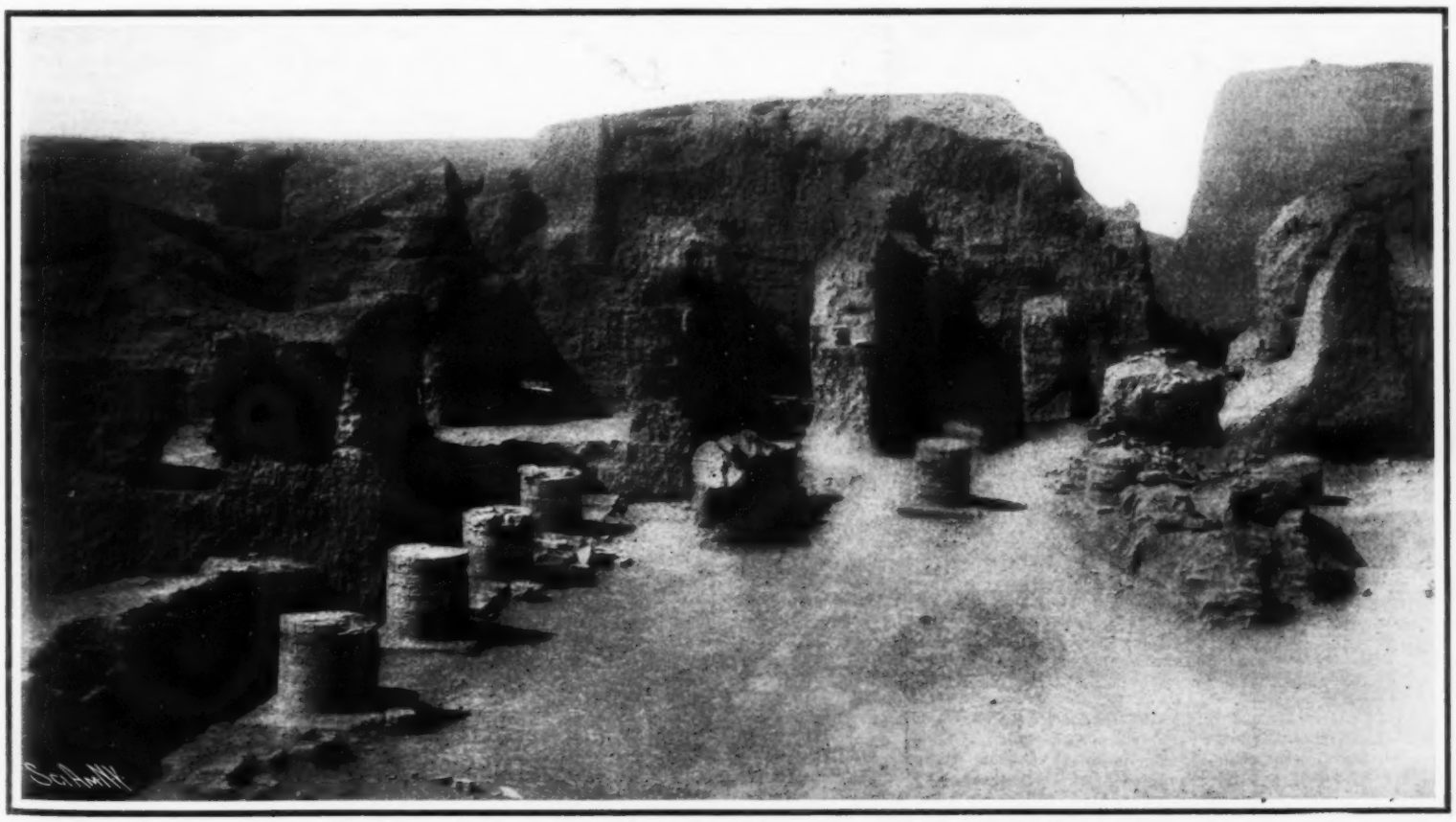


FIG. 3.—THE PALACE AT NIPPUR, LOOKING OVER THE GREAT COURT FROM THE NORTHEAST.

THE MYCENAEAN PALACE AT NIPPUR.

west corner disclosed some curious additional evidence. To understand this, one must know that all the main walls inside and outside of the palace were constructed of unbaked bricks about 12 inches square and 5 inches thick. Over these was applied a coating of mud plastering. All the columns and antae in the building were of baked brick covered with lime mortar. Now all over the palace these inside walls are reddened to a depth of from 1 to 5 inches, leaving the inside still the grayish brown of the original clay. This is the same in the west corner, but with a curious addition. Here the walls have two distinct layers, so to speak, of red. The inner part is unbaked, with a layer of reddish, crumbly clay on each side. Then there is a second layer of good fresh clay on each side, with a final reddish layer outside. This at once proved to me that we had to consider two destructions by fire and not only one. Before this I had been considerably puzzled by the presence of a large quantity of burnt grain found in the room marked XXI on the plan (Fig. 1). It could not have been stored there while the palace was occupied, because room XXI appeared to be the only outlet for all the rooms to the south of it, as well as the key to the system of communication between the eastern and western halves of the palace. Further excavation fully established the importance of this room beyond any doubt. How, then, are we to account for its being so full of burnt grain? The discovery of the evidences of a double destruction supplied the clew. In the rooms in the western corner only does this double trace occur; in all the others there is the simple evidence of but one fire. Further searching disclosed the remains of a doorway cut in the main northwest wall at the point *a* in room XXXIX. The sill of this was considerably above the former floor of the room, and on a level with the top of the hearth in the adjoining room (XXXV). It was clear that after the first or great fire the western part was rebuilt, either at that time or soon afterward, and used as a small dwelling, with several of the rooms, especially XXI, which was now at the rear of the new house and hence the most secluded, set apart as storerooms. Naturally, the old walls, where damaged by the flames, were reinforced and patched, restored to the required height, and then covered with a new roof. Then this in its turn was destroyed by fire, and it was at this time that the grain was burnt. Just as we might expect, this burnt grain was found only in the rooms in this west corner, as indicated by the dotted patches on the general plan (Fig. 1).

These two periods of the building must really be considered as one, and these differences do not affect our chronology at all. This hypothesis accounts for the better preservation and height of the remaining walls of the one part of the palace as compared to the others. The east side of the building, and especially the east angle, has suffered most from the weather, being exposed to the washings of a gully which evidently owes its origin to a surface conduit which formerly drained the great court on this side.

We can surely allow for at least so long a period between the destruction of the palace and the third pavement as intervened between that and the two superimposed strata. On the other hand, we have the building resting directly upon the remains of the Cassite period, c. 1200 B. C. Eight hundred years before the Parthian era would give us an outside date of 1000 B. C., so that we must place the construction of the palace somewhere between these two dates, i. e., between 1200 B. C. and 1000 B. C. This corresponds to the date of the latter end of the Mycenaean age in Greece, and we have abundant evidence, not only from smaller objects from various parts of Nippur, but in the detail of the palace, that there was in existence there at that time an influence in art too utterly un-Babylonian and too closely Mycenaean to allow any room for doubt as to whom we are to thank for the erection of the interesting edifice.

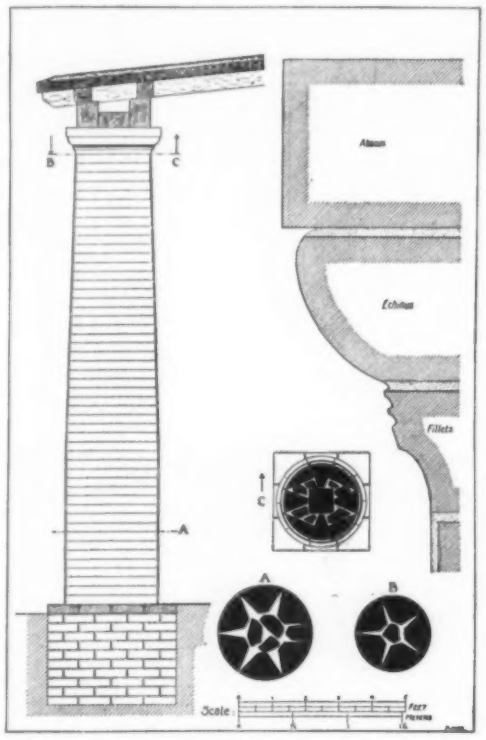


FIG. 2.—DETAILS FROM THE PALACE AT NIPPUR: THE COLUMNS IN THE PERISTYLE COURT.

THE PALACE.

The palace is practically square in plan. The northwest and southwest sides, which are the only ones remaining in their entirety, are respectively 172 feet 2½ inches and 169 feet ¼ inch long. The diagonal of the building is 19 deg. 30 min. east of north, being so placed to take full advantage of the warmth of the sun in winter and the cooling breezes in summer, which would naturally have a greater effect when two instead of only one side was turned toward them.

The angle between these two walls is an exact right angle, and while it was evidently the intention of the builders to make all the angles so, a slight distortion of the sides of the central court makes the plan slightly irregular. The axis of the northwest row of columns is parallel with the northwest wall, but the axis of the southwest row makes an angle of 90 deg. 10 min. with it, and this in turn is at an angle of 89 deg. 30 min. with the southeast row, with the result that the rooms in the south corner are not rectangular. The outer wall on the southeast side follows the corresponding line of the court, and so apparently did the fourth side parallel the northeast side of the court, although we have but a fragment of it remaining.

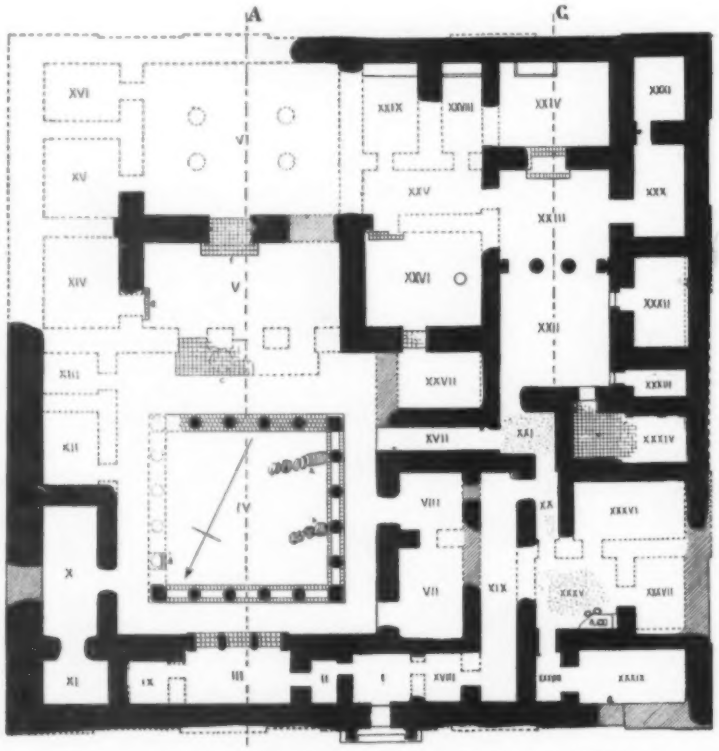


FIG. 1.—GENERAL PLAN OF THE PALACE AT NIPPUR.

The outer walls on three sides are decorated with shallow pilasters, while the fourth side, toward the canal, is much heavier and simpler in design, in accordance with the character of a retaining wall to the terrace which existed on this side, as is shown by the remains of buildings of the same period as the palace on a much lower level at the foot of the wall, and nearly against it.

The plan can readily be divided into two parts, Fig. 1. The eastern half, the *andronitis*, grouped on the axis *A*, is marked by a general spaciousness and appearance of publicity and state. Its court, vestibule, and hall are large and well lighted. On the contrary, the effect of the western part (*G*) is privacy and domesticity. There is a noticeable absence of decoration and display; the rooms are smaller and more compact. It is impossible that these two parts are separate houses, for not only have they but one common entrance at I, but the two are closely connected by the passage XVII. The fact that this latter passage is protected by strong doors at either end does not argue against this view, for it was an arrangement by which the inner part of the house could be kept more private during the presence of strangers in the public apartments.

The single entrance I have mentioned is on the northwest side. Fortunately, it was so completely uninjured by the ruin of the rest of the palace that we could secure a very correct idea of it. The doorway is 5 feet 6 inches wide, and placed in the center of one of the decorative pilasters. Three broad, low steps, constructed of baked brick, led up to it. The lowest of these forms a base for the entire feature, and the second, by returning around the fronts of the two pedestals placed at each side of the opening, forms a plinth block for the moldings composing their bases. The pedestals are carefully constructed of baked brick, and their rough faces finished with a layer of fine stucco. The face of each, instead of being perpendicular, has a graceful curve outward from the base. Both the moldings of the bases and caps have the oval form characteristic of the Greek work and not the simpler semicircular contour common to the Roman curves. The whole has a height of over 4 feet, but the wall above is so damaged that it is impossible to determine what rested on the pedestals. The door admits to the general vestibule (I) of the palace, from which two doors on the left and right sides of the room lead to the *andronitis* and *gynaeconitis* respectively. The doors in the vestibule and the two anterooms (II and XVIII) adjoining it are so placed that a view of the interior of the palace could not be obtained by any one standing outside in the street, or even in the outer vestibule itself.

We will first describe the apartments of the *andronitis*. Passing through the special anteroom (II), we reach a sort of large loggia (III) corresponding to the *prothyron* in the earlier types of Greek house. Its whole southeastern side is open to the great court (IV), the main wall of which is carried over the opening on two elliptical columns *in antis*. There is no pavement in this loggia, nor, indeed, in any of the rooms of the palace, the floors being composed of clay well worked down and rolled. Edges of steps where most wear would come were protected by curbs or edgings of baked brick one or more rows in width, such as we find here running under the columns along the low step which leads to the level of the colonnade around the great court. This peristyle has been considerably damaged by the construction within its limits of burial vaults in later times. In plan, three of the sides are well preserved, but in elevation the columns and corner piers remain standing only from two to four feet. A portion of the foundation belonging to a column on the fourth side determines the position of that side, and shows that the colonnade extended around this side as well and had the same width as on the other sides. This floor was also unpaved, except for a curb of two rows of bricks with a space between them running between the columns. On the southeast side there were four rows of bricks laid closely together. This curbing was continuous under the columns and was but one course in thickness. Below each column was a foundation of baked brick 4 feet square and extending 3 feet below the level of the colonnade. By a study of all the lower portions of columns left standing, and from the two fallen ones at *a* and *b* on the plan, of which *a* was complete, I have ascertained the original height and system of construction of the columns. The diameter at the base was 2 feet 9 inches, and the height about 13 feet 6 inches, a ratio of base to height of approximately 1:5. There were fifty courses of bricks in each column, exclusive of the capital, and for the first seventeen of these the sides were perpendicular. Above this an entasis gradually lessened the diameter until at the top course it was only 2 feet 2½ inches, or nearly in the ratio 3:4 as compared to the base. These are the proportions of the Doric column of the earlier type, and, as we shall see later, the columns were crowned with the unmistakable Doric cap having the earlier form of echinus.*

* These columns are not of the form exclusively considered as Mycenaean. It is now becoming more and more widely recognized that the Doric type is not widely different from the Mycenaean, but has so many points in common with it that we can now say it owes its origin to it. Hence at such a late date in Mycenaean art as the years of the emigration of part of the Mycenaean people, slightly subsequent to which I place the erection of our palace, it is not surprising to find that the columns had already reached the somewhat crude but unmistakable Doric form which is found in the palace at Nippur.

The builders were accustomed to using stone, so that when they were forced to use clay for the same purpose they had to display considerable ingenuity in order to obtain with it columns of the desired form and size. Having decided from the rest of the building the height of column required, their hereditary instincts of proportion compelled them to have a certain diameter at its base and top. They molded the clay into the shape of sectors of a circle and baked them, making them all of a common size to economize time and labor. These they used to construct their columns. It was puzzling to find that the lower courses of the columns contained not only a certain number of these sectors, but always had a small extra fragment of brick inserted, with the apparent object of giving a greater diameter to the column, but that this arrangement was not uniform throughout the entire column. For instance, in the lower seventeen courses there were six sectors with a wedge, *A* in Fig. 2. At the top there were five sectors without a wedge. A study of the courses between showed that the entasis was obtained by gradually decreasing the size of the wedge above the seventeenth course until just six sectors completed the required diameter.

Then five sectors with decreasing wedges were used until at the top there were, as I have said, the five single sectors (*B* in Fig. 2). It is evident that the builders desired to have the top built as solidly as possible to make a sound base on which to support the girders and beams of the roof, whose direct weight came at that point. If they had made the sectors large enough to form the bottom diameter without the use of wedges, they would have been unable to form the top courses without using a specially large wedge, thus defeating their purpose. So the sectors were designed to make a good joint at the top, and the courses at the bottom, where the mass of the shaft above made it unnecessary to have such careful jointing, were left to take care of themselves. The shape of the sectors resulted in a large space being left in the center of the column which was filled with fragments of broken bricks. The column was trimmed off with some sharp tool and then finished with a coat of stucco.

The construction of the capital is equally interesting. It was composed of bricks cut on their edges to form the contours of the Doric cap. These were not molded, but were cut after the bricks had been baked. One series of bricks contained the fillets which joined the necking of the column with the echinus above, and other bricks had the outline of this echinus. Of the fillet bricks we found two distinct shapes, each with exactly the same molding, showing that they formed part of the same structure. One of these was sector-shaped like those used in the body of the column, while the other appeared to have been cut from a half-square brick. I found that when a pair of them were placed as shown in this figure, their combined ornamented edges formed part of the circumference of a circle with a diameter corresponding to that of the top of the shaft, with the addition of a slight projection necessary to cover the edge of the stucco with which the rough sides of the latter were coated. At *c*, Fig. 2, is shown the whole arrangement of this capital. The echinus, of which we found but one unbroken specimen, was composed wholly of sector-shaped bricks. The absence of any bricks forming the square abacus leads me to believe that this was not constructed of bricks at all, but was most likely a large, thick piece of planking on which the girders of the colonnade roof rested and to which they could be securely fastened. On the left of Fig. 2 is the column restored with a suggestion of the system of roofing, based upon that employed in the country at the present time, evidently a survival from earlier periods. On the right is a full-size detail of the capital, showing the fillets, echinus, and abacus with their connection to the main part of the shaft and its stucco.

While the width of the colonnade was uniform on three of its sides, on the southeast side, in front of the door to the *prodomos*, it widened out. Here there was a broad pavement with the base of a large round structure (*c*) at one end. This was certainly the altar which we find in every Greek house, situated somewhere in the main court near its principal axis. There is nothing left of the wall between the great court and the *prodomos* (v), and we can ascertain its proportions only from the extent of the pavement forming the step to the door. Charred fragments of the roof beams were found here and also around the edges of the colonnade. Naturally the center of the court was open to the sky in order to supply light and air to the rooms around it.

The discovery of the threshold (*f*) of the *megaron* (VI) was as important as the finding of the front entrance. Three steps lead up to a door which is over 10 feet wide. At either side of the top step were door-sockets, and in the débris and ashes lying there were the remains of the bolts and bars used on the door. These are significant from the fact that they were entirely of iron while all the rest of the metal work in the palace was of bronze. This use of iron on the principal doorway of the palace is intelligible when we remember that at the period the palace was built iron was rarer and more valuable than bronze, the metal commonly used for weapons and implements. Iron was selected for the ornamentation of the chief door, just as silver or bronze would be in our own day. The whole of the front wall of the *megaron* is intact, or was before the portion shown by shaded lines had been removed by a trench during the early days of excavation. The rest of the walls are fragmentary. A portion of the rear outer wall gives us the depth of the room and parts of the two side walls give us the length. It was some 37 feet by 48 feet, a nobler hall than that at Tiryns. No traces of support for the roof were found, but I have indicated four columns grouped in the center supporting an opening clerestory after the system used at Tiryns. This gave exit to the smoke from the low hearth which must have been here and also admitted the light which could not have come very well from the outer court through the dark *prodomos*. Various smaller rooms were grouped around the great court. Of these, two (VII and VIII) were almost complete. Room IX, having its only outlet through the *prothyron* (III), was evidently a small guard room commanding the entrance opposite. Rooms X and XI were, with VII and VIII, sleeping rooms for the inhabitants. At the east end of the *prodomos* (V) a low step indicated a door to a room on a lower level than the great hall, and used with the several other restored rooms here served the same purpose. Fig. 3 is a view across the great court through the door of the *megaron*, in the foreground. Beyond, on the right, is the base of the altar with the columns of the peristyle behind it.

Near the south corner of the court there was a step with a door which opened on a long passage (XVII) connecting the main court with a small vestibule (XXI). The two door sockets at either end of this passage enabled it to be securely closed at will against intrusion by persons in the great court. The vestibule (XXI) could be reached from the front door through the winding passages (XIX) by first entering the women's vestibule (XVIII) and then following the passage (XIX and XX). The smaller corridor (XX) was used as an anteroom to the group of slaves' rooms in the west part of the palace (XXXV to XXXIX), and kept the regular women's quarters apart from them.

We find, again, in vestibule XXI an arrangement of doors to prevent the curious from observing what went on in the women's court (XXII) like that employed at the front entrance. This court, as we have said, was much smaller and simpler than the main one. There is no colonnade, but only the open porch on the south side screening the women's hall behind it (XXIV). A flight of steps led up to the door of the latter, but no door sockets were found on its threshold. This whole group of court, porch, and hall is parallel to the similar group on the men's side and is arranged in the same order. To the east of the small court and connected with it by a corridor (XXV) were two rooms which deserve special mention on account of their importance.

They were, no doubt, the private rooms of the owner. The inner apartment (XXVII) was the bedchamber and the large outer hall (XXVI) used for entertainment or receiving personal visits. The outer room was on a lower level than the corridor or the inner room, a step leading down into it from the former and up from it into the latter. At its west end there was a single fragmentary column which probably supported a gallery over the end. On the opposite side of the corridor were two long storerooms (XXVIII and XXIX). Along the western side of the court were two more good-sized rooms, from one of which (XXX) there was a strong door leading to a small dark room (XXXI) which was the treasure room of the palace.

One of the most interesting features of this side of the building was the bathroom (XXXIV). This opened from the west corner of the court near the door leading to the passage to the men's apartment.* Its floor was tiled with baked brick, and there was a low rim around the sides formed by laying a row of bricks on edge. Both floor and rim were laid in bitumen, instead of mortar, and thickly smeared with it. From all sides of the room the floor sloped to a point in the center opposite one jamb of the door, where a small round hole allowed the water to escape into a vertical drain made of the common round pottery sections. This was still seventeen feet deep.

The whole of the west corner was given up to a series of rooms belonging to a distinct group having its outlet through room XX. This was the regular working department of the palace. Room XXXV was a kitchen, with a raised hearth (*a*) in one corner, constructed of unbaked brick with a single course of baked brick on top. At one end was a ledge and in the middle was a spit composed of two pieces of stone, the upper one hollowed out, and having two grooves cut in opposite sides in which the metal spit turned. Two water jars stood leaning against the sides of the hearth.

The discovery of this interesting palace at Nippur, so closely following in its details the more widely known one found at Tiryns, gives us additional proof of the wonderful extent of the civilization which scholars, for want of a more exact name, have designated as Mycenaean. Further excavations at Nippur and at other Mesopotamian sites may throw light on the dark question of the authors of this civilization, but I do not believe that such will be the case. Instead, I believe we shall find that this part of the nearer East was the last influenced by the Mycenaean culture and this was due to its being the place to which some Mycenaeans migrated after their expulsion from the mainland of Europe by the Dorians. Already we have some slight reasons for this belief in the curious gap in the otherwise very full chronology of the Babylonian and Assyrian empires. From *c.* 1100 B. C. to 950 B. C. we have a period full of unrest, of vague and mysterious mentions of strange races invading the land, who are called in one part of the country by one name, and in other parts by another, and finally the total absence of records of the descendants of the older dynasties. Not until the later date do we find them reasserting themselves and reviving their ancient kingdoms with some degree of strength and prosperity.

* At Tiryns the bathroom was situated on the men's side of the palace.

THE SEARCH FOR PLATINUM.

OWING to the increased demand for platinum, the United States Geological Survey is about to make an examination of the platinum resources of the United States. It is proposed to collect the heavy sands from all placer mines in the United States where evidences of platinum have been observed. The samples thus obtained will be used in determining the best methods of extracting the various minerals which have economic value. It is hoped that the separation and sale of these useful minerals, such as magnetite, chromite, garnet, monazite, rutile, zircon, gold, platinum, etc., will, in many places, become a permanent and profitable industry.

As a preliminary step to this investigation, the Survey invites the owners of placer deposits to contribute for examination samples of material likely to contain platinum. These samples, which should be sent by mail, must weigh not more than four pounds each. It is suggested that the gravel be concentrated before it is mailed. Careful note should be made on the package, or in a letter accompanying it, of the total quantity of original gravel which the concentrate represents, in order that an accurate idea may be obtained of the value of the gravel for the purposes under investigation. The sand should be dry when mailed and great care should be exercised to pack it securely, preferably in canvas bags, for transmission through the mails. Each package of sand should be accompanied by exact information as to the name and postoffice address of the sender, the name of the mine or claim from which it came, and the State, county, city, village, or district in which the deposit is located. It is desirable that the owner of each deposit should state what efforts have previously been made to separate platinum from his sand or from other sands in his neighborhood.

After the Survey has made an examination of these samples, experts will be sent to all localities where preliminary tests give evidence of platinum. The expert will report on the size of the deposit and superintend the collection of representative samples for concentration. Experiments in the concentration of platinum sands will probably be carried on in connection with the exhibits of mining machinery at the Lewis and Clark Centennial at Portland, Oregon, between June 1 and October 15 of this year.

As a help to prospectors, the Survey publishes the following facts about the qualities of platinum:

Pure platinum is a silvery white metal with a specific gravity of 21.5. With the exception of iridosmium it is the heaviest metal occurring in nature. It is almost as hard as iron and is very malleable. Platinum does not amalgamate with quicksilver, is not dissolved by potassium cyanide when cold, is not attacked by acids except the mixture of nitric acid and hydrochloric acid known as *aqua regia*. It is more difficult to melt than gold.

Native platinum has been found most frequently in gold-bearing sands. On account of its weight it remains in the sluices with gold and other heavy material. It is most readily distinguished by the following characteristics:

1. Its great weight.—In panning it remains behind even gold in the pan.

2. Its white color.—It is whiter than lead and is distinguished from amalgam by its smooth surface, whereas the surface of amalgam as seen under a good glass is rough.

Native platinum is usually very impure; occasionally it contains so much iron and so many other impurities as to be dark in color and not easily distinguished from chromite, with which it is commonly associated. It frequently contains iridosmium, which occurs as flat, angular scales, while platinum grains are usually rounded, like gold dust. Platinum grains are usually smaller than gold grains. Large nuggets are very rare.

Platinum seems to be more generally distributed through California than through any other State. It has been found in Butte, Del Norte, Humboldt, Mendocino, Placer, Plumas, San Luis Obispo, Santa Barbara, Santa Cruz, Shasta, Siskiyou, Tehama, Trinity, and Yuma counties. Curry, Coos, Lincoln, and Josephine counties in Oregon have produced platinum. It has been discovered in Nez Perces County, Idaho. A nugget of platinum was found in Rutherford County, North Carolina, in 1847, and one in Clinton County, New York, in 1880. Platinum has been reported from Custer County, Montana, from Lumpkin County, Georgia, and from the beach north of Lituya Bay, Alaska. It has been detected by assay in sands from Lancaster and Montgomery counties, Pennsylvania. The richest producer of platinum in the United States is the Rambler mine, of Albany County, Wyoming.

Although artificial gas has a heating value of only from 650 to 700 British thermal units per cubic foot, and a thousand cubic feet, costing in many American cities about $1, contains approximately one-thirty-sixth the heating value of a ton of anthracite coal, hence costs six times as much as coal at $6 a ton, yet, on account of its advantages of convenience, cleanliness and adaptability, gas has obtained a strong foothold as a means of heating buildings. It is particularly valuable for intermittent heating of such buildings as churches, lodge rooms, and other meeting places where heating is required for short periods only during each week. With coal heating a large portion of the heat is wasted, inasmuch as a heavy fire has to be started which perhaps lasts some hours after the need for it is over. With gas heating the fire is easily

started, and while it must be started some time previous to the time the heat is required, of course, it can be discontinued immediately after such need is over; but from the point of economy gas heating should be done by gas radiators located in the room. These should be provided with suitable ventilating devices so as not to vitiate the air with the products of combustion.—Machinery.

IMPULSE AND REACTION TURBINES.*

A QUESTION frequently asked by those studying the steam turbine is "What is the distinction between the impulse and reaction turbine?" Both water and steam turbines are grouped into two general classes known as impulse and reaction turbines, and to make clear the distinction between the two types, it will be necessary first to give an explanation of the terms "impulse" and "reaction."

MEANING OF IMPULSE AND REACTION.

A reaction is a force acting in a backward direction. According to older writers in mechanics, an impulse is a force acting in a forward direction. Strictly speaking, this is not correct. An impulse is not a force in the sense of being a push or a pull, but is a term used to express the same meaning as momentum, when the force acts for a very short space of time, as when one body gives another a sharp blow. When we speak of an impulse turbine, the older meaning of the term is usually implied to distinguish it from a reaction turbine; but it would be more consistent to speak of the two types as action and reaction turbines, as in fact is sometimes done. Even these terms, however, would be somewhat misleading, because all practical turbines operate both by the action and reaction of the working fluid, and it would be better to designate the two classes in some other way.

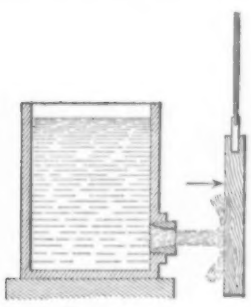


FIG. 1.

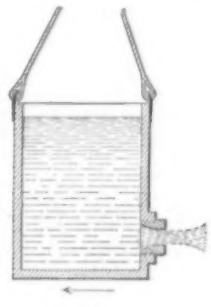


FIG. 2.

In Fig. 1 is a tank from which water issues through a nozzle and impinges against a flat surface capable of moving horizontally—in this case the face of a plank suspended so that it is free to swing. When the water strikes the plank the latter will swing to the right under the pressure due to the impulse of the jet. As the jet leaves the nozzle, however, it exerts a reaction or backward kick against the tank, which is equal and opposite to the force due to the impulse of the jet. This may be illustrated by suspending the tank, as in Fig. 2, so that it is free to swing, when it will move to the left, owing to the reaction of the jet.

The explanation of the reaction is that there is no pressure on that part of the tank where the nozzle is situated and the unbalanced pressure on that part directly opposite to the nozzle will therefore tend to move the tank in a direction opposite to that in which the water is escaping. The faster the water escapes, the greater the pressure required in the tank to give the water its velocity; and hence the greater the unbalanced pressure which we call reaction. It is on this principle that a gun "kicks." If a blank cartridge is fired, the pressure due to the burning powder acts one way against the bottom of the barrel and the other way against the air and the former pressure produces the reaction. If the gun is loaded with a bullet it requires a higher pressure in the barrel to start the bullet on its course, and the reaction or kick is greater. Assuming the bullet to absorb all the energy of the charge, the momentum of the bullet would be equal to the momentum of the gun at the time of firing; but the gun, being many times heavier, would fortunately have much less velocity.

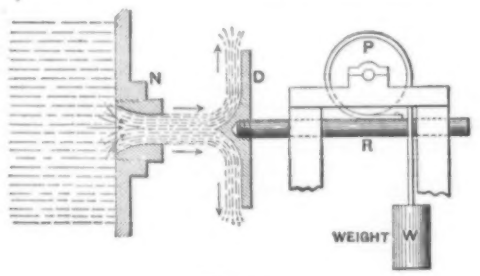


FIG. 3.

IMPULSE AND REACTION UPON CURVED VANES.

In Fig. 1 the velocity of the jet is suddenly checked when it strikes the plank, and there is more or less commotion of the particles of the fluid, causing loss of energy. This is always the case when there is impact of particles against a surface and is to be avoided by using a curved surface so placed as to change the direction of flow gradually without shock or jar. Such an arrangement is shown in Fig. 3, where a nozzle *N* is discharging against a plate *D* attached to the rod *R*.

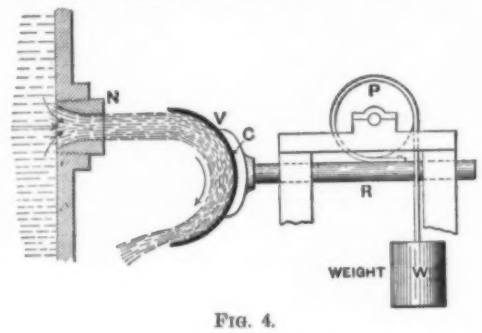


FIG. 4.

The rod is supported by guides and together with the plate can move longitudinally. The pressure of the jet against the plate is balanced by the weight *W* supported by a cord passing around the pulley *P* and attached to the rod *R*. The plate *D* is so shaped at the center as to gradually guide the particles of water through an angle of 90 degrees, thus avoiding the impact present in Fig. 1, and the particles leave the plate in a direction parallel with its face. It is evident that the pressure against the plate is due solely to the impulse of the jet and that the reaction of the water in leaving the plate has no tendency to move the plate longitudinally.

In Fig. 4, however, the case is different. Here the water strikes a curved surface and is turned back upon itself through an angle of 180 degrees. This surface is therefore acted upon by two forces, both tending to move it to the right. The first is that due to the impulse of the jet, just as in Fig. 3, which acts until the central point *C* of the curved surface is reached; and the second is the reaction of the jet, which begins where the jet starts to flow backward and continues up to the edge where it discharges. Both of these forces would be equal if there were no frictional or other losses, and it would require a weight, *W*, just twice as heavy as the weight in the first example to balance the end thrust.

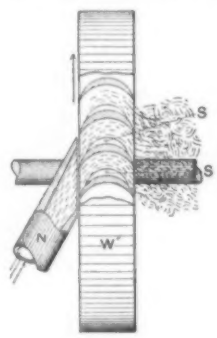


FIG. 5.

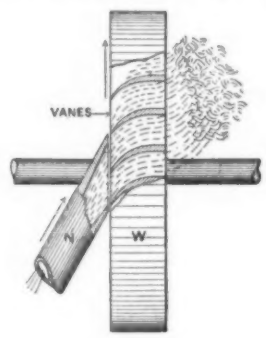


FIG. 6.

IMPULSE TURBINES.

All turbines known as impulse steam turbines, like the De Laval, for instance, operate on the principle of Fig. 4. The turbine wheel has curved vanes, as in Fig. 5, against which the jet of steam impinges. The expansion of the steam is completed within the nozzle, and there is no expansion in passing through the wheel passages. The pressure between the vanes is the same as the pressure within the casing in which the wheel runs, and the steam flows freely through the wheel passages in virtue of the momentum given it in the nozzle. The wheel is driven ahead, first by the pressure due to the impulse of the steam and then, after the vanes have reversed the direction of flow, by the reaction of the steam.

In Fig. 5 *N* is the nozzle, which may or may not be a diverging nozzle, according to the pressure against which it is discharging, and *W* is the wheel. With the vanes constructed as shown, there would be spaces *S S* not filled by the steam, since the area of the passages at these points is greater than at the entrance and exit. Some manufacturers, however, make the blades thicker at the center than near the edges, to maintain a constant area and so avoid possible eddy currents. Although a so-called impulse wheel, it will be evident that this wheel acts both by impulse and reaction. The chief characteristic of this type is that the expansion occurs wholly in the nozzle or guide passages, as the case may be, and the steam flows freely through the wheel in virtue of its momentum, without expanding or acquiring additional velocity in the wheel passages.

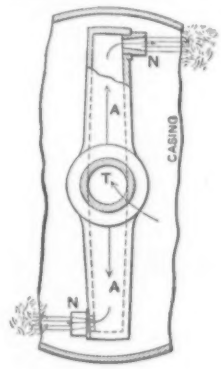


FIG. 7.

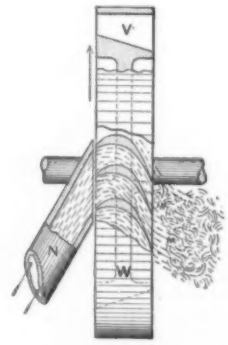


FIG. 8.

What would strictly be an impulse wheel is shown in Fig. 6, where the vanes are so curved that when the wheel is held stationary the steam leaves them in a direction parallel with the shaft. The wheel is therefore propelled solely by the pressure against the vanes due to the impulse of the steam, and would be inefficient because the steam would have a high residual velocity when it left the wheel. Such a wheel is on the principle of the stationary vane in Fig. 3, against which the water exerted only half the pressure that it did when the force of reaction was taken advantage of.

REACTION TURBINES.

In Fig. 7 is the simplest type of reaction wheel. Here the steam enters the trunnion *T*, flowing radially outward through the two hollow arms *A A*, until it discharges through the nozzles *N N*. The arms therefore rotate in a direction opposite to that in which the steam escapes, and are driven entirely by the reaction of the steam. The chief difficulty of this type of wheel is the excessively high speed of rotation. Supposing the wheel to be perfectly free to move, its momentum would be equal to the momentum of the escaping steam. The velocity of the arms therefore would be less than the velocity of the steam only in so far as the mass of the arms was greater than that of the steam.

In Fig. 8 is shown a more practicable form of reaction wheel. Here there is first the impact of the steam against the buckets, but the expansion in the nozzle is only partial and the steam expands still more and acquires additional velocity in flowing through the wheel, provision being made for this, if necessary, by having the passages diverge in the direction of the flow, as at *V*. The steam therefore reacts upon the wheel when it leaves the vanes as a result of the energy acquired in the wheel itself, and this feature gives it the name of a reaction wheel. It will be seen that the wheel acts both by the impulse and the reaction of the steam just as in the case of the impulse wheel. The distinction between the two, however, is that in the impulse wheel the expansion of the steam is complete within the nozzle and in the reaction wheel it is not completed until after it enters the wheel passage. If it were possible to attach a steam gage to one of the spaces between two wheel vanes, it would show a pressure equal to the pressure of the medium in which the wheel was turning in the case of the impulse turbine, and a pressure higher than that of the surrounding medium in the case of the reaction turbine.

* Reprinted from Machinery (New York).

STEAM AND STREET RAILROADS IN THE PHILIPPINES.

ONLY a beginning has been made in these means of transportation in the archipelago. The only steam railroad of importance runs from Manila to Dagupan, a distance of 122 miles. It traverses a rich and populous valley and carried in 1902 over a million passengers and over 165,000 tons of freight. The gross profit for the year 1902 was $373,703. Two short extensions of this road are being built.

Three lines of street railway, operated by horse power, and a steam railroad running four miles represent the transportation facilities of Manila at the time of the census. These lines were owned by a single company. During the year 2,626,606 passengers were carried on the street cars. Since 1902 a modern electric railroad, operated by overhead trolley, has been substituted.

Land transportation in the rural districts is difficult, and during the rainy season often impossible. The repair and construction of roads is receiving the generous attention of the insular and provincial authorities.

The principal systems of telegraphic intercommunication in the islands were constructed by the United States Signal Corps to facilitate military operations, but were speedily thrown open for commercial and private use. Subsequently arrangements were made for the gradual transfer of the lines to the civil government. There were over 10,000 miles of telegraph and telephone lines and submarine cables in operation, about one-fourth of which were but temporary in character. In addition to the cable system installed by the Signal Corps, a private corporation controls insular marine cables connecting several of the larger towns, and owns the cable system to Hongkong, formerly used for communication with the United States. The establishment of a direct line from Manila to San Francisco, via Honolulu, has lessened expense and delay.

The land and marine telegraph systems of the archipelago are modern in type and construction and are equipped with improved appliances. The railway company operating the line from Manila to Dagupan maintains a telegraph system of its own. The value of the marine and land lines, controlled by the United States Signal Corps, the insular government, and private corporations, was estimated December 31, 1902, to be $1,544,174. During 1902 the Signal Corps employed in the islands an average of 600 men. The telephone facilities consist largely of the military telephone lines under the control of the United States Signal Corps, and the civil government lines operated by the con-

stationary. In Manila a third system is also in use—a commercial system owned and operated by a private corporation.

MAKING OILED ROADS.

By A. S. ATKINSON.

CALIFORNIA has the best and the worst stretches of roads to be found in this country; the best because they have been carefully made by a new process, and the worst because of the fearful dust clouds which hover over them in summer. Her need of getting rid of the summer dust has led her to desperate experiments; and in efforts to find some way out of the difficulty, California has solved the problem for the whole Pacific coast, if not for the rest of the country.

The modern oiled roads of California should not be confounded with dusty roads that have been sprinkled with oil to lay the dust. Of all nuisances to automobilists and pleasure-seekers, the ordinary country road sprinkled with petroleum is probably the most obnoxious. The oil is everywhere—on plants, bushes, trees, vehicles, and clothes. It has a perverse way of finding vulnerable spots in one's suit of armor, so that after a trip over the road the smell of oil is forever associated with the experience. Even railroads which have sprinkled their roadbeds with petroleum to lay the dust and cinders have practically been forced to abandon the practice, because of the damage done to the clothes of passengers.

California has entered upon a road-making era that is peculiar to her climate and soil, and some of her oiled roadbeds are the finest in the world. The roads are made only by careful preparation and thorough work. They are plowed and harrowed, oiled and rolled, graded and smoothed until their surface is as level and inviting as a billiard table, and almost as free from dust.

The first process is to plow the road to a depth of a foot or more, using reversible sidehill plows drawn by six or eight horses. With a deep subsoil plow the earth is cut into clods, so that the whole road looks like a newly-plowed field in the spring. After the plowing laborers go over the road to break the clods in pieces. If the road has been oiled before, these clods are sometimes so hard that a sharp blow with a beetle is required to break them. If the road has never been thus treated with oil, it is sometimes possible to dispense with the hand labor, and ordinary clod-crushers or rollers will pulverize the soil sufficiently. A spike-toothed harrow breaks the clods into smaller pieces, and frequently two or three harrowings are required, alternating with the roller.

Heavy iron rollers drawn by four horses are used to crush the particles into smaller pieces, and after that the grader is employed to give a proper slope to the sides to shed the water. The arduous preparation of the roadbed makes for permanency, and when once finished it will last a long time. The oil is not applied until the soil ten or twelve inches deep has been completely pulverized, graded, and rolled, so that to the eye the road appears almost perfect. Then the oil is sprinkled over it, to compact and bind together the minute particles.

The oil is applied heated at a temperature of 175 to 300 deg. F. The heating of the oil is expensive, but it makes all the difference in the world as to the final result. The hot oil will run down into the finely-pulverized soil, and when cooled it will bind the particles closely together. When applied cold, the oil practically stays near the surface, and a strong wind can blow the dirt up, spreading the oily particles over field and farmyard. The hot oil is carried in huge sprinkling tanks from the heating plant to the roads, and from 120 to 300 barrels are distributed over each mile of road. All depends on the width of the road and the importance of the thoroughfare. Some of the roads which are subject to constant and heavy traffic receive as many as 350 to 400 barrels of oil to the mile.

After the oil is applied, a second sprinkling a few weeks later is sometimes made to insure perfect binding of the sand and dust. Then a top surface of coarse sand or gravel is applied to absorb any loose oil on top, and also to protect vehicles from coming in contact with the oil. When thus finished with its top surface of fine gravel, the oiled road is as clean and perfect as any macadamized road in the East. In spite of heavy wind storms, no dust is blown up from these oil-treated roads, and one may ride over them in the face of a heavy wind with as much comfort as if the road had been recently sprinkled by an April shower.

There are over a thousand miles of such oiled roads in California, and they are the most beautiful thoroughfares for motor riding found anywhere in the country. On all sides the tropical nature of the country adds beauty and attractiveness to the scene, and during the hot, dry summers a spin across California can be enjoyed to-day as never before. The oil gives a dark-brown appearance to the sandy roads, and this instead of spoiling the effect proves of great advantage by relieving the eye of the white glare.

A newly-oiled road naturally stains wagon wheels and motor tires which come in contact with it, but after a few weeks of use the oil settles into the soil, and scarcely any stain is visible. Tires are not affected by the oil. California oil is composed of asphaltum and petrolene. The former is a solid brittle substance which forms a part of the roadbed in time, and the latter is a viscous liquid which scarcely changes at all when spread over the road. One proves a dust-absorbent, and the other a binder for the soil.

California oil sells from 65 cents to $1 per barrel, and it is this relative cheapness of the commodity that makes it possible for the town and county authorities to employ it so freely in road making. Nowhere else, except possibly in Texas, could such apparent extravagance be justified. However, Texas, which has a great many miles of sandy soil, and an abundance of oil wells, has entered into making oiled roads; and if similar success is attained there, the motor rider may soon be able to cross the Lone Star State on good roads, as he now slides down the Sierra Nevada Mountains to the Pacific Coast without any of the inconveniences that formerly made California a State to be avoided in summer. It is true that most Easterners visit California only in the winter, but there is something in the climate and country in summer on the Pacific Coast that makes a tour across the State eminently desirable at such a season.

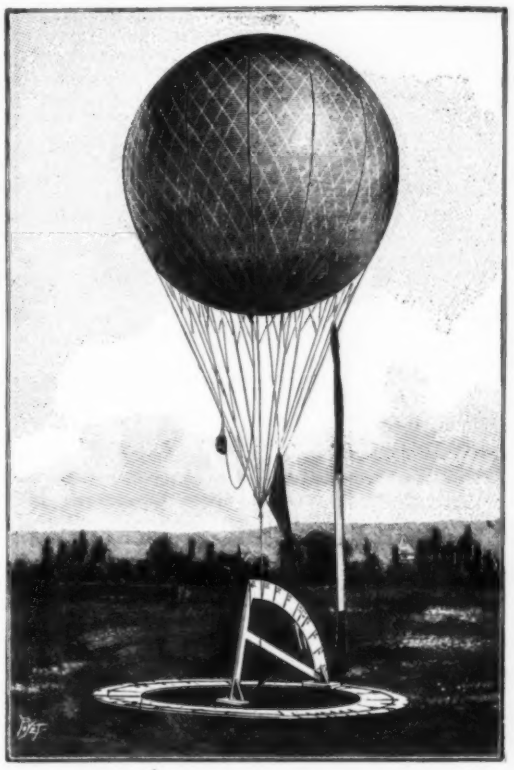


FIG. 1.—APPARATUS FOR MEASURING THE DIRECTION AND VELOCITY OF THE WIND AT DIFFERENT HEIGHTS.

THE JULLIOT ANEMOMETRIC BALLOON.

AERIAL navigation does not as yet possess semaphores for indicating the state of the weather, and yet this is a datum without which it would sometimes be imprudent to embark for the celestial solitudes. The wind in particular is so preponderant a factor in voyages made in a steerable balloon that it is indispensable to have some information in regard to it. Wind-vanes and anemometers installed upon the shed in which the balloon is housed may, indeed, furnish some indications as to what is taking place at a slight distance from the ground, but the aeronaut might experience a disagreeable surprise upon reaching the zone of navigation, since the wind is a capricious element which varies greatly with the altitude. When making free ascensions, it is customary to send up beforehand small pilot balloons which easily mark the general direction the balloon will take, but are totally lacking in precision for determining the speed. In this regard, steerable balloons are placed in more favorable conditions than free ones, since they are designed for navigating in a zone without limits and at a relatively low altitude. The Lebaudy balloon generally remains at a height of a little over three hundred feet. It would consequently suffice to study the movement of the anemometer over a region of from 200 to 300 yards; and this would permit of operating by means of captive apparatus, balloons, or kites.

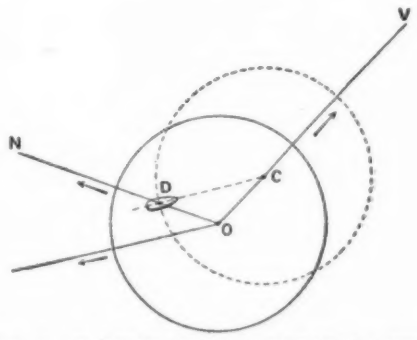


FIG. 2.—GROUND PLAN INDICATING THE OPERATION FOR DETERMINATION OF THE PROW.

M. Julliot, the engineer of the "Lebaudy," has devised for this purpose a captive balloon, which is now installed in Moisson Park, and which has given excellent results. This balloon, which is of varnished silk, has a capacity of 100 cubic feet. It is inflated by means of relatively impure hydrogen, which escapes at the beginning of the production of the gas for the inflation of the steerable balloon. The inflating tube is tied in order to prevent losses, and a small safety valve placed at the lower part prevents any chance of bursting. The balloon carries an altitude-registering apparatus and a banner. In addition, an electric lamp, actuated by a dry battery and placed in the center of the balloon, illuminates the latter at night. The balloon raises a steel cable of very small diameter wound around a windlass placed in a shed. The cable passes over a pulley, the block of which, having a universal joint, follows it in the inclinations that it is capable of assuming in oscillating around a pivot imbedded in masonry. This pivot is in the center of a horizontal circle 13 feet in diameter, formed of wood and divided like the rose of a compass containing the winds. It suffices to arrange a wooden sector in the vertical plane of the cable, and have its center coincide with that of the large horizontal circle, in order to determine, in the first place, the azimuth upon such circle and afterward the inclination, in degrees, of the cable at its start. When the ascensional force of the balloon is known, it is possible, from the inclination, to quite easily deduce the force of the wind, at night as well as in the daytime; and, in order to complete such indications, the oscillations of the captive balloon and those of the banner show the greater or less regularity of the atmospheric current.

This is not all. The inventor of the apparatus has marked upon the horizontal circle the direction of the principal surrounding localities, along with their distance.

As the diameter of the large horizontal circle is 13 feet, its radius represents precisely, on a scale of 1/20,000, the distance made in one hour by the steerable balloon, the speed of which is 25 miles an hour. Use has been made of this property for practically indicating to the steersman the direction in which he must put the prow in going and returning. For this purpose there is employed an auxiliary circle formed of iron tubing, and of the same diameter of 13 feet, which is laid upon the ground in such a way that its center shall be in the direction of the wind and at a distance from the stationary center representing on the scale the hourly velocity of the wind, say *O C*. If the velocity of the wind is 15½ miles, *O C* will equal 49.21 inches on the scale of this vast plan.

The balloon would be situated at the point *C* at the end of an hour, if it had no means of propulsion. If it moves of itself at 25 miles an hour, it may, on the contrary, reach some point of the auxiliary circle, and if it is to reach a locality situated in the direction *O N*, all that has to be done is to seek the point at which such direction intersects the auxiliary circle (at *D*) in order to have its position at the end of an hour, the line *C D* marking the route traversed by its own means. In multiplying this length by 20, we shall have the real distance. In order to proceed without deviating from the direct route the balloon will have the prow turned constantly in the direction *C D*.

This very suggestive diagram is merely the beginning of the figure on a larger scale by which is demonstrated the very principle of aerial navigation. M. Julliot has here made of it a very judicious application, which is capable of rendering the greatest service to aeronauts.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

AGRICULTURAL PRODUCTS OF THE PHILIPPINES.

THE most important commercial product of the islands is *abacá*, or Manila hemp. This is indigenous to all provinces, but the fiber is unlike the hemp of other tropical countries, and is found only in the Philippine Islands. The value of the exportations of this product exceeded $19,000,000 in 1902, or was two-thirds of the value of all exports. Nearly all of this material is shipped in the raw state to Europe and America for manufacture into cordage. Although a large area was devoted to the cultivation of *abacá*, much of the product that was exported was gathered wild.

The exportation of the dried kernel of the cocoanut, known as copra, is steadily increasing and promises to become of great commercial importance. The value of the exports of copra and cocoanuts for 1902 was $2,701,783. The cocoanut palm flourishes luxuriantly in the Philippines, and when its products are systematically harvested, it is a source of unfailing revenue and profit, supplying several by-products of commercial value.

The demand for rice throughout the archipelago far exceeds the domestic supply, and it will probably be necessary to continue to import it indefinitely, as the cultivation of hemp and other products is much more profitable. It is probable that the cultivation of cacao, from which chocolate is derived, will greatly increase and become one of the principal products of the islands, as the cacao of the Philippine Islands is superior to that grown anywhere else in the world.

PHILIPPINE MANUFACTURES.

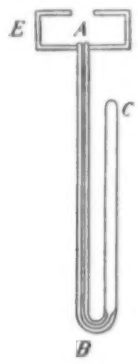
THE production of sugar, although really an agricultural industry, has been included under manufactures. It is proportionately of much importance in the Philippines. The number of establishments whose products amounted in value to at least 1,000 pesos each was

1,075, and the total value of the product was 6,603,006 pesos. There were in addition many hundred small sugar mills that produced low-grade sugar and were too primitive and unimportant to be included in the census schedules; the aggregate of such establishments, however, would be considerable. Negros Occidental is the most important sugar province, and in it are located 291 out of a total of 528 steam-power sugar plants in the archipelago. The value of sugar exported in 1902 was $3,342,473, or 12 per cent of the value of all exports. Including sugar, the total number of manufacturing plants in the archipelago is 3,259, and the total value of products is 41,700,215 pesos.

In commercial importance tobacco is the third agricultural product, the value of the manufactured article being a little more than half of the total value of all the tobacco exported, which amounted to nearly $2,000,000 in 1902. Measured by value of product tobacco outranks all other products of the Philippine Islands, and the output of 113 establishments for 1902 was valued at $8,740,516, which is about 25 per cent of the total value of manufactures for that year. The products of liquor and tobacco constituted 37.4 per cent of the value of the insular manufactures as compared with 4.8 per cent for the United States. Sixty-seven per cent of the total value of manufactures, exclusive of sugar, is reported by the city of Manila. The capital invested in manufactures in the Philippine Islands exceeds 50,000,000 pesos.

THE PIESMIC BAROMETER.

A new mercurial barometer, which has been designed by Mr. A. S. Davis, M.A., and has been called by him the Piesmic barometer, is an ingenious adaptation of an easily understood principle in the relation between pressure and volume in gases; and presents as practical advantages several new features of convenience, lightness, and trustworthiness. The action of the instrument depends on the fact that any volume of air taken at a low pressure is more compressed than an equal volume of air taken at a higher pressure, when the pressure on each volume is increased by the same amount. The following is a description of the method of the instrument, which is of so convenient a size that it could, without very much inconvenience, be carried in the inner pocket of an overcoat.



ABC is a glass tube, the part *AB* being made of strong capillary tubing of one-tenth inch bore and *BC* being made of thin quill tubing. *AB* is seven inches long, and the capacity of the whole tube is thirty-five times the capacity of a single inch of the capillary tubing. The end *A* opens into a small cast-iron cistern *E* containing mercury. The air in this cistern, though not in actual communication with the external air, is kept at atmospheric pressure by communication with a small auxiliary chamber, the sides of which are of thin paraffined paper. When the tube is horizontal the mercury lies on one side of the cistern, leaving the open end *A* of the tube exposed to the air. When the tube is brought into a vertical position the mercury flows over and closes the mouth of the tube, then flows down the tube to a greater or less depth, the depth being dependent upon the atmospheric pressure at the time. If the barometer is standing at 30 inches the mercury will descend 5 inches; if at 29 inches it will descend 6 inches; if at 28 inches, 7 inches, and so on. A scale of inches being placed behind the tube, the reading of the end of the mercury column against this scale shows the height of the barometer at the time.

PATTERN MAKING.*

By R. Watson.

Twenty or thirty years ago pattern making and millwrighting were considered joint branches of engineering, but gradually as competition and more complicated work came along it was found that a man, to become thoroughly efficient, must devote his whole time to one branch. This subdivision has again taken place in the pattern shop of recent years. Iron pattern making has become quite a separate section. This includes the fitting up of iron patterns, turnover plates, and all stripping plates, etc., required for molding machines. Again, where molding machines are used men are kept on the special patterns that are required for them until they become quite experts at this class of work.

It is not the writer's intention to deal with these special kinds of patterns (each is important enough in itself to form a separate paper), but to confine himself to his actual experience of wood patterns. It may be well to consider the material used in pattern making. Timber merchants have at various times advised several different kinds of wood, such as kauri pine, American white wood, teak, and jarrah, etc., but experience has proved that they are not as suitable for pattern construction as Canadian pine and the mild straight-grained mahogany of Tabasco and Belize. Timber for standard patterns should be carefully selected, as there is a considerable variation in the quality of yellow pine. It is not unusual to find a shipment of pine altogether unsuitable for pattern making. It may be free from shakes and knots but has the defect of being hard in places, which is known to the pattern maker as being "strong." Timber of this kind

Fig. 1.

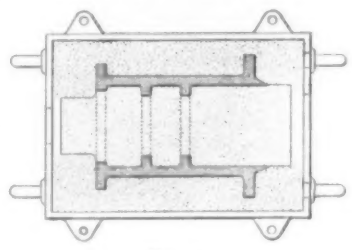


Fig. 2.

has a great tendency to twist and warp, and if worked up into patterns proves costly in repairs, as it will not keep its shape so well as the milder quality. Yellow pine planks should be at least three years old. Weather-seasoned wood invariably works better than that artificially dried. Where large standard patterns are made it is advisable to have good stocks in hand of various thicknesses of a first quality; also a second quality, which may be used for temporary patterns, loam-boards, etc. Experience shows that this tends to great economy. It should be carefully stacked and stored so that it is kept out of the sun and rain, allowance being made for free passage of air between each plank.

The circular saw, band saw, planing machine, thickness planer, and lathes are indispensable tools. The hand trimmer might also be classed among them, for it considerably cheapens the production of patterns, especially of that class which are built up in segments. The introduction of pneumatic tools into the pattern shop is among the latest labor-saving devices. Portable drills and chipping hammers are finding a useful place on large work; they have this advantage, that they can be brought right on the work during the different stages of construction when it would be impossible to move the work to the different machines. Chipping hammers fitted with a gouge tool are very handy for removing surplus wood to form curved surfaces in patterns and core boxes, doing the work from four to six times faster than is possible with hand tools. Pneumatic drills almost dispense with the pattern maker's brace and bit and perform the work very rapidly and with considerably less labor to the man. In large pattern shops where standard patterns are made machines such as the "Moore" carving machine and "Wadkins" mechanical wood worker can be kept profitably employed in corebox making, recessing to different levels, and in the many different operations which are performed in the making of complicated patterns these can be done more accurately and quicker than by hand.

It is in the pattern shop that the engineer and draughtsman first see the actual thing which they have designed. Many views and sections may be given, but there still remain points which have to be left to the judgment of the pattern maker, such as the development of curves, rounded edges, fillets, etc., all of which go to make the symmetry of the whole. Upon receiving a drawing in the pattern shop, if the work is at all complicated, it is set out full size, but in some cases sections only that are required for the construction of the pattern and arrangement of cores. Machining allowances are shown. All the setting out is done to a contraction rule, so that any dimension which may be taken is the pattern size.

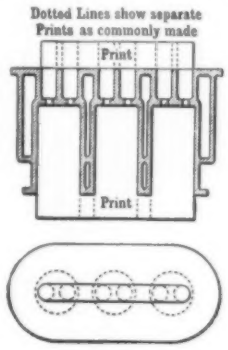


Fig. 3.

In some works the foreman or leading hand sets the work out. The writer prefers that each pattern maker should set out his own work, as by so doing he makes himself familiar with all the details. He is then in a position to discuss the construction of the pattern, method of molding, and arrangement of cores. It is usual for the principal dimensions to be checked by the foreman. The first thing that has to be determined is the best way of molding, and if it is likely to be a permanent or temporary pattern. The chief things that govern the molding are the principal machined surfaces; these are placed in the bottom of the mold to insure them being clean and free from defects. If it has to be machined all over, or top and bottom, extra machining should be allowed on the top side. This should be plainly marked on the pattern before being sent into the foundry by different colored paint or written instructions. Another point to be settled is the readiest way in which the cores can be put in the mold. In some cases it is almost impossible to fulfill the foregoing conditions and to get the cores in the mold in such a manner that the molder can make provision for getting the air or gases out of the cores.

Patterns should in all cases where possible be parted and doweled together on the joint line of the mold, as in the case of a cylinder through the center line of the circle, so that when the top part of the molding box is lifted off, the portion of the pattern covered by it is taken with it. Then the molder can loosen each part separately and see what he is doing in drawing the pattern from the mold. It is advisable to lift the pattern from the mold rather than the mold from the pattern. If the molding box has to be lifted off, leaving the pattern behind, it often results in some portion of the mold breaking down, which sometimes costs a large amount of time to repair. Then it is not true to pattern and very often gives a badly shaped casting due to the patching up of the mold.

Loose pieces, such as bosses and facings, although objectionable, cannot in all cases be avoided. On permanent patterns these should be fixed on by a dovetail. On temporary patterns a screw or wire pin will do, provided the position of the piece is well scribed round on the body of the pattern. Where several pieces have to be loose near each other, it is as well to leave one large piece of the pattern loose containing them all, provided there is sufficient room in the mold to allow this being drawn in. Another method of getting over the difficulty of several loose pieces is to put them all together in a core. The objection to this is that in dry sand work it often leaves a mark on the casting if the core cannot be put in green and dried with the mold.

In constructing large patterns wide pieces of timber should be avoided because of the shrinkage and expansion. Frames made of narrow pieces and half lapped together at the corners can often be used with advantage. These are stronger and retain their shape better than large flat pieces. There is also a considerable saving of timber by this method. Patterns made of dry timber will expand when left in the mold for any length of time and contract when stored away. In boarding up large surfaces, open joints, say, ¼ inch between each joint, should be left. All screw-holes should be bored larger than the diameter of the screw to allow free movement when the boards expand or contract. Where possible the grain of the wood should run in the direction that the pattern is going to be drawn from the mold. As little end grain as possible should be left exposed to the sand. If it cannot be avoided it should be placed so that it is the first portion of the pattern which leaves the mold when it is drawn out. If it is in the bottom of the mold the other way of the grain will shrink and leave the end grain projecting, which will pull a part of the mold up when the pattern is drawn out. This is often the cause of the molder having to do a considerable amount of sleaking to the mold.

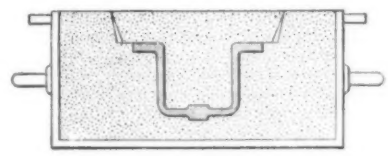


Fig. 4.

In large patterns, such as bedplates, etc., good provision should be made for rapping and lifting, as it adds considerably to the life of the pattern. In the joint or side of the pattern from which it is going to be lifted from the mold, stout timbers should be put in to receive rapping plates, connected to the bottom of the pattern by struts or stays. Lifting bolts or straps should go through the body of the pattern. In cases where bolts are used there should be a plate let in level with the bottom of the pattern and screwed to receive the bolt. Where this system is practised it is usual to have all lifting plates screwed one size, when one bolt will do service for several patterns. The screwed end of the bolt should be well tapered off to give it a lead into the bottom plate. The top end should have an eye at least two inches in diameter, so that it will receive the hooks which are in general use around this class of work in the foundry. There is a certain amount of suction in lifting a pattern from the mold in addition to the weight of the pattern itself. Then there is the question of taking the pattern backward and forward to the pattern stores. If lifting irons can be relied upon, it is better to lift by them than by rope or chain slings, for these generally leave their mark on the pattern. In fact, heavy standard patterns are often more damaged in lifting about than in actual use in the foundry.

The question of taper is often a very debatable sub-

* Paper read before the Rugby Engineering Society.

ject between the pattern maker and the molder. It is seldom the molder complains of there being too much, but excess of taper often means more machinery than is necessary. There is no standard rule; each piece of work requires separate consideration. In most cases ⅛ inch to the foot is found to be sufficient. On castings that have not to be machined it is customary to make the given dimension half-way down the pattern, so that the pattern at the top of the mold is over the size and at the bottom under the size. If taper were shown on the drawings, on deep surfaces that have to lift vertically from the mold, it would save an amount of time in fitting brackets, etc., on what are supposed to be vertical faces. The brackets would then be designed to suit the taper. On the inside of ribs and brackets, where size is of little consequence, more than ⅛ inch to the foot may be given, provided it does not look unsightly or add much to the weight.

In complicated patterns sometimes pieces are left so that the molder has to lift a part of the mold away before he can draw the pattern out, or, in other words, make a "drawback." This is an expensive method to the foundry. It can often be overcome by a core print being put on the pattern and a box made to suit. It incurs extra cost in making the pattern; still this fact should not be lost sight of, that it only has to be done once in the pattern shop, but every time a casting is made off the pattern in the foundry. If this extra cost is divided by the number of castings required, it will be readily seen that the "print and core box" is often the cheaper method to produce the casting; for this should be the aim of the combined efforts of both pattern maker and molder. Where the core method is used great care must be taken that the piece which forms the part of the core matches the mold; if it is possible this piece should be worked on the pattern in its place, then taken off and put into the core box. This will insure getting a good joint and only a very slight mark on the casting.

Prints that lift vertically should have more taper than other parts of the pattern. In no case should the taper be less than ¼ inch to the inch. The size of the core is the size of the print near the pattern. In prints where the core comes through the top molding box for convenience of centering or releasing the core, etc., the size of the print is still kept the right size near the pattern, but tapered larger to give clearance for passing the core down, as shown in Fig. 1. No two prints on a pattern should be the same size, or nearly the same size, or probably the mold will be cored up wrong. In prints that mold horizontally the root should have a slight chamfer on it, as shown in Fig. 2, as the edge of the mold breaks down when the core is put in. If this is not done the molder generally takes it off with his trowel each time he makes a mold.

Cores are often more difficult than the outside of the pattern; it often takes considerable time to arrange them so that they may be put in the mold in the readiest possible way. Circular core boxes are generally doweled together on the center line for convenience of ramming up and getting the core out of the box. Intricate boxes often have to be made in several parts; where any doubt exists as to the best way of making it, the core maker should be consulted as to the handiest way for him to arrange for his core irons and vent passages. Large sized boxes should be made so that they can be taken to pieces, and the corners rabbeted together so as to insure them being put together in the same place, and not trusting entirely to the screws going in the same holes. In boxes for standard work wood screws should not be used, as the constant taking them in and out wears the holes, and the core is made larger than required. Bolts should be used for screwing the boxes together with suitable shaped handles or wing nuts. These are more quickly released than wood screws and soon save the extra cost. In no case should the ordinary hexagon nut be used, as the time that should be saved is lost in hunting for a spanner of the right size.

In large cores allowance has to be made for the expansion of them in drying; one-sixteenth inch to the foot is found sufficient if the cores are dried at the usual rate. This point (which is not recognized by some pattern makers and molders) is often the cause of considerable delay due to the time taken in rubbing the cores down to give the required thickness of metal. After the core has been dried the best test is to try and place it in the box in which it has been made. It is accounted for by the core iron expanding while the core is being dried, and pushing the sand out with it. The core iron contracts in cooling, but the sand on the outside of the iron is baked hard and does not move back with it.

Large cores should, where possible, be made the same way up as they are to be put into the mold, for convenience of getting at the iron to lift them by when fixing.

Where cores have to bore out to exact centers in relation to each other, as in the case of motor cylinders, where two or three boxes are in the same casting, these should be made in one core box tied together by continuous prints at both ends as shown in Fig. 3. This admits of a good stiff core iron which can readily be broken without any risk of breaking the casting. It is a quick method of coring up, as all the bore cores are put in at one operation, as well as keeping their centers exact, at the same time simplifying the molding of the pattern.

Where diaphragms, valve facings, etc., on the inside of the casting, have to be put in a particular position in relation to the outside of the casting, a key must be put on the core and its print. This should be put on the joint of the mold where it can be seen when coring up. It is often found useful to make the print on the pattern smaller than the required size of the core, so as to form a shoulder on the core, as shown in Fig. 2. The core can then be put up to the end of the mold. This will give it a definite position lengthways independent of the ends of the print, from which the molder often finds it convenient to cut the sand away. This shoulder should be made in proportion to the size of the core; it must not be less than ⅜ inch, increasing up to 1½ inch in large cores. If it is made too small it will get a thick coat of blacking and do more harm than good. In small cores where great accuracy is required and where the metal is very thin the core should be made about 1-32 inch smaller in size than is required, to allow for blacking, and care must be taken that the cores fit their prints, for when once rubbing is commenced on the core no two castings will be identical. In this class of work the first casting that is made off a pattern should be cut up to see that all parts are of the required thickness.

Core boxes that are made to suit taper prints should be the exact size at the point where the casting commences, but should be slightly less than the top of the print; this will insure them going in easily and tightening themselves when they are down in their right position. Core boards that are to be used for cores of which large quantities are likely to be required should have a thin sheet of iron on the striking edge, filed to the exact shape of the board. On the top side two strips of iron should be screwed on, giving the exact size of the prints into which the core is to fit; otherwise, after a few cores have been made, the board gets worn and often gives considerable trouble both to the molder and machinist.

Large work, such as condensers, flywheels, pipes, etc., are usually swept up in loam, very little pattern making being required, as loam boards are used to make both the inside and outside, all projections having to be built in the mold. Work of this type is usually cast upon end. These do not contract the ordinary amount; 1-200 inch to the foot is found to be sufficient to allow in this class of work. Loam work as a rule takes more time in the foundry than when a pattern is used. No doubt it is the correct method to follow when two or three castings only are required, but when this amount is exceeded the cost of a light skeleton pattern, against the extra time each casting will take to make, should be considered. A case of this kind was given in the American Foundry Journal some time ago, where an American company had six sets of large engine castings to make. The first one or two of each of the larger pieces were struck up. Afterward it was decided to make patterns and molding boxes to suit. In finishing the remainder it was found to be both cheaper and quicker and the castings better to shape. This question is often settled by the tackle that exists in the foundry, for plates, binders, etc., required for loam work are expensive items. Another way of handling work of which only one or two castings are required is to make the outside in cores. This can often be done very economically, for one or two core-box shells with different internal fittings may be made to do duty for all the cores required. This method cuts the pattern making down to a minimum. In large work of this class, especially, the pattern maker and molder should try to avoid getting into set grooves of working, for the method has yet to be found that is economical and suitable for all work.

Light castings, such as covers, caps, cone pulleys, etc., may be made so that the core takes the place of the top molding box and is self-centering, as shown in Fig. 4. This core must be at least 1½ inches thick and 1 inch larger all round than the casting, so that it will bear sufficient weight being placed on it to withstand the lift while the mold is being poured. The print should have a large taper; this makes it simpler both for molding and coring up. It is important in this method of work that the core fit its print, and that no blacking is put on that portion of the core which goes into the print. Patterns of this description, if they are circular, should be built up in segments, or framed up if square.

All circular work on standard patterns larger than about 10 inches diameter should be built up in segments; it has the advantages of being stronger, does not shrink or expand, and retains its shape better than when cut out of the solid wood. The "trimming machines" now used in most pattern shops have cheapened this class of work. Built-up work often can be made to leave its own core with advantage, and to save the time and material that would otherwise be spent in making a core box. The writer does not recommend building up flanges, etc., in less than three courses; in fact, two courses are very little better than when cut out of the solid. In pipes, cylinders, etc., "lagging up" is resorted to when the diameter of the work is large, partly to economize material and to secure a form which will be least affected by the distorting influence of shrinkage and expansion. Lags are usually made from 3 inches to 5 inches wide and the number that go to make up a diameter is determined by the size which can be cut most economically out of the width of a plank. In large diameters the rings on which the lags are fixed are built up in segments; this makes a very light but rigid pattern. This method of lagging up is not confined to circular work only, but is used on curves wherever a radial line can be fixed. There is often a difference of opinion as regards the right amount of contraction to allow on special large work, but the writer thinks that most people are fairly well agreed that for general castings 1 in 120 is found to give the most reliable results and most pattern-makers' rules are now made to this allowance. Steel and malleable iron of different makers often vary much in the contraction. In large size castings in these metals the safest way is to ask the founder what contraction should be allowed; on small work the following data can generally be relied upon: General iron, 1-120; loam work cast vertically, 1-200; brass, 1-64; phosphor bronze, 1-100; steel, 1-48; aluminium, 1-74; malleable iron, 1-64; lead, 1-48.

Painting and Varnishing of Patterns.—Various opinions are held by pattern makers on this subject, but all agree that patterns, except those of the most temporary kind, should be painted or varnished, as it preserves the pattern and fills up the grain of the wood, so that the sand does not cling to it when the pattern is being withdrawn from the mold. One good method that is practised by some of the larger firms is to paint "black" parts that are not to be machined, "yellow" parts that are machined, and "red" for prints and parts where the core cuts through the metal. In parted patterns the section is painted in the joint. This method enables the molder to see at once what parts are going to be machined. It also shows him the arrangement of the cores and the thickness of metal, so that he can see where to cut the runner gates to the best advantage, without having to correspond the core boxes with the pattern; thus saving the time which would be taken in doing so. It also assists the pattern storekeeper in getting out the different core boxes belonging to a pattern without having to refer to his book or getting the tracing to see how many core boxes are required.

Upon finishing a pattern all center lines should be cut in deeply with a scriber; this makes it much quicker to check the pattern, and also make any alterations to it, as most of the principal dimensions are given from the center lines.

Makers of different kinds of machinery have a system of marking their patterns best suited to their own class of work. Standard patterns generally have the marks cast or in raised letters or figures; this mark should also be stamped plainly on the pattern, core boxes, and all loose pieces that are used with it. A method that is now being employed for small patterns is to have the "pattern mark" stamped on a strip of aluminium by an automatic machine; this gives a fairly good mark on the casting if a little extra care is taken by the molder.

In conclusion, it may be well to add that in making patterns they must not be considered as finished articles, but as means which are employed to produce castings. With this aim in view the work should be so distributed between the pattern shop and foundry that upon receipt of an order for castings it will result in their delivery with economical dispatch.

The author wishes to thank Mr. C. Morehead for valuable help given in the preparation of this paper.

A GIGANTIC IRRIGATION PROJECT.

THE Payette-Boise irrigation project in Idaho has received the formal approval of the Secretary of the Interior, who recently set aside the sum of $1,300,000 for initiating the work of construction. This action on the part of the secretary has been anticipated for some time, and is largely the result of the splendid enterprise of the citizens of that section. For more than a year the land owners, organized into a water users' association, have labored indefatigably to harmonize the many conflicting claims of private interests in lands, canals, and water rights, with the result that to-day practically the valley as a unit stands pledged to the government enterprise.

Briefly stated, the Payette-Boise project provides for the reclamation of 372,000 acres of land in these valleys, 300,000 acres of which are now in a desert condition. It is proposed to irrigate 72,000 acres with the waters of Payette River, 54,000 acres of this area being situated in the Boise Valley; 25,000 acres situated on the south side of the Snake River, a portion of the latter area to be supplied with water from that stream, the water to be pumped by means of power which will be developed at the diversion dam on the Payette River. The remainder of the water which will be used on this tract will be furnished by Succor Creek, a tributary of the Snake River. The remaining area of 93,000 acres is situated in the Boise Valley, and will be watered from the Boise River. Of the lands in the project, about 71,000 acres are public lands subject to entry under the conditions of the Reclamation Act. About 46,000 acres have been entered to date under this act; about 60,000 acres belong to the State of Idaho, and the remainder, about 195,000 acres, are in private ownership, held in tracts averaging about 100 acres each.

Ample storage facilities exist on the head waters of the Payette River, which will be available for regulating the discharge of that stream, and which can be developed at very reasonable cost. The principal storage for the Boise lands is in the valley proper along the line of the power canals. Some storage can also be obtained on the head waters of this stream, and utilized for the irrigation of lands situated above the level of the reservoirs on the plains. It will be entirely feasible to develop a supply of water for the late irrigation of practically all of the lands under the project, as about 100,000 acres of land within the limits of the project are already irrigated.

This work has been accomplished through individual and community effort and private enterprise, but has not been planned on very comprehensive lines, and the communities have made no provisions for the full development of the natural resources of these valleys. The plans which must necessarily be adopted in order

to accomplish the best results, owing to the magnitude of the undertaking, are beyond the reach of community effort; nor do they offer an attractive field for the investment of private capital. They can only be carried to completion by the help of the government.

The broad plans which the Reclamation Service have under consideration contemplate the construction of a diverting dam in Payette River, and of a canal for the same on the south side of Payette Valley for the irrigation of the lands thereunder, or about 18,000 acres. This canal will also conduct water through the divide between the two rivers to 54,000 acres in the Boise Valley. A diverting dam on the Boise River, and one or more canals and storage reservoirs will distribute water to 241,000 acres of land on the south side of Boise Valley, while a canal on the north side will irrigate 33,000 acres. Storage reservoirs on the head waters of the Boise River will furnish water for the late irrigation of about 75,000 acres of land along the line of the upper canal. The complete utilization of Succor Creek on the south side of Snake River, supplemented by a pumping system from the latter stream, will supply 25,700 acres.

ELECTRIC GENERATING STATION, TRUCKEE RIVER.

WARD SHAFT, COMSTOCK LODE.

PUMPING THE COMSTOCK LODE MINES.

By CARL GEORGE P. DE LAVAL.

FOR years numerous efforts have been made to unwater and explore the entire Comstock lode. The latest move in this direction has just been made by the Ward Shaft Association, consisting of a group of the middle mines, composed of Gould & Curry, Savage, Chollar, Potosi, Bullion, Alpha Consolidated, Exchequer, and the Julia Consolidated Mining Company, who own and operate nearly a mile of the middle lode.

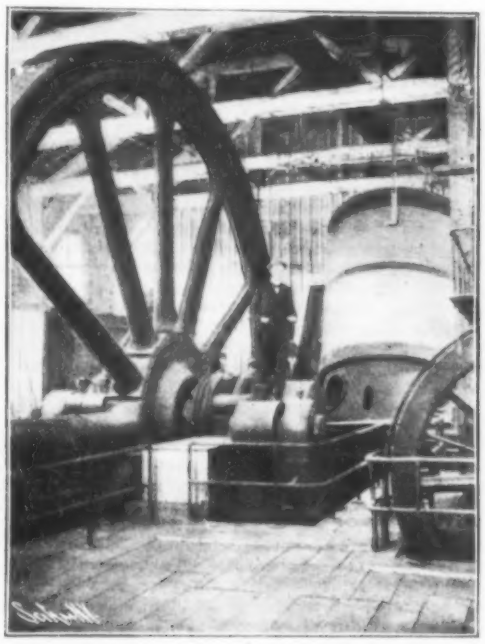
It is now about twenty-six years since the largest pumps of the steam-actuated type were installed in these mines, but since then science has progressed in the development of pumping appliances to such an extent that it would be an injustice to criticise the types that were then in use, comparing them with modern up-to-date equipments. Moreover, the reasons and causes for adopting the types then in use are now forgotten. Suffice to say it is with admiration that we look upon the great efforts and successful designs that were applied in former years by the veteran engineer, Mr. W. R. Eckart, of San Francisco, before the completion of the Sutro tunnel.

The responsibility of successfully demonstrating that the later types of pumps will accomplish the exploration of the southern portion below the 2,500-foot level has fallen on the shoulders of Mr. Leon H. Hall, chief engineer and superintendent. The northern half has already reached a depth of 3,000 feet, with very good returns from the deepest parts, and there are known to be large mineralized bodies below the 2,500-foot level in the middle and southern parts, where the inrush of water about twenty years ago flooded all the middle mines up to the 1,600-foot Sutro tunnel level. All these levels have been idle, and it is Mr. Hall's belief that it is possible to unwater, ventilate, and successfully and safely work the levels as deep as 5,000 feet.

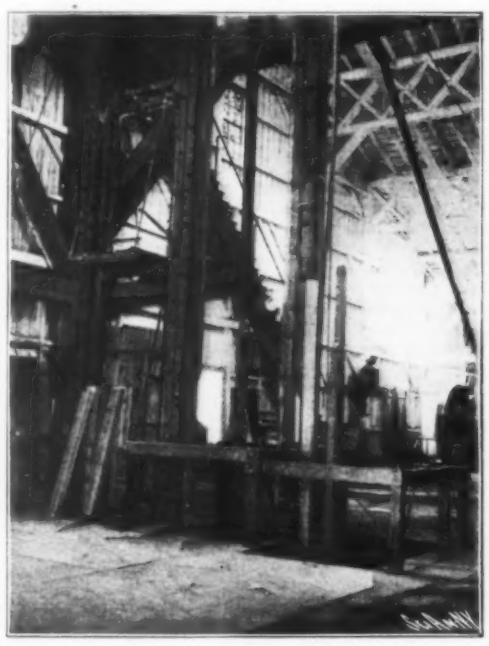
No known mining district in the world has encountered greater difficulties than the Comstock. The water that was encountered twenty years ago on the 2,900-foot level of Exchequer mine in Gold Hill was 170 deg. F. in temperature, and the temperature of the station and workings about 110 deg. After various efforts to handle this inrush of water, it was finally decided to allow the water to fill to the Sutro tunnel. About ten years ago another effort was made to unwater the mines through Crown Point incline, which also was abandoned after an expenditure of about half a million dollars, and future workings were confined to the 1,500-foot level.

At this time hydraulic pumping engines were installed, together with various Cornish engines, altogether of a capacity to keep the water at the 3,300-foot level in the northern mines; but the expense of operating was so great that the mines were allowed to fill up to the 1,600-foot level, and workings were confined to the more accessible ore bodies above the Sutro tunnel. The fact that the deposits which have been worked at the higher levels continue at the lower levels has induced the mining companies to try every known expedient in order to reach them. Therefore, about four years ago a large hydraulic lift was installed at the Consolidated California shaft, and with this appliance the water level in the north end has been kept below the Sutro tunnel level at about 2,150 feet, and a considerable amount of valuable ore has been taken out, amounting to over $1,000,000. Having reached this level, another effort was made to go lower, installing an electric pumping plant of the most modern type, consisting of three Reidler electric pumping engines driven by 200-horse-power induction motors. These pumps take the water at the 2,150-foot level and, together, discharge 4,500 gallons per minute into the Sutro tunnel under 430-foot head. The hydraulic pumping engine serves as a sinking pump, discharging into a tank at the Reidler pump.

The application of electricity on the Comstock, not only in pumping, but in hoisting and for general use in mining, was introduced about four years ago by Mr. Leon H. Hall. The power is generated on the Truckee River, about two miles east of Floriston, where McCormick turbines are directly connected to Westinghouse three-phase generators of the revolving armature type. Each pair of wheels will develop about 1,400 horse-power under a head of 84½ feet. Regulation is effected by Lombard governors. The generator potential of 500 volts is raised to 24,000 volts by Westinghouse oil-insulated transformers, and the current is transmitted about 35 miles to Virginia City over a double circuit of copper wire. The mining companies purchase power from the Truckee River General Electric Company, the amount used being based upon a peak load of two minutes' duration when the electric hoists are operated directly upon the lines. The price is $7 per horse-power per month. There is about 200 horse-power of apparatus installed on the Comstock lode which will soon be increased to about 5,000 horse-power, as a contract has lately been closed between the Truckee River General Electric Company and the thirty-two mining companies comprising the Comstock Pumping Association, which calls for the delivery of electric power for draining the Comstock mines, lighting, hoisting, etc., the maximum amount being 5,000 horse-power. In order to fill these contracts for additional power, the Truckee River Company has prepared plans for a second electric generating station and a new pole line. Water will be diverted from the Truckee River and conducted to the extreme eastern end of the company's hydraulic system, where it will be utilized by waterwheels under a head of 141 feet. For the maximum of 5,000 horse-power the rate will be $4.50 per horse-power per month, with proportional rates for lesser amounts. This is based upon motor readings, and will save the mining companies a considerable amount of money as compared with the existing contract. All motors of 50 horse-power and over are operated directly on 2,240 volts, all smaller motors on 440 volts, and the lighting circuit is 220 volts, three-



ORIGINAL PUMPING ENGINE AT UNION SHAFT.



TYPICAL COMSTOCK HOIST.

PUMPING THE COMSTOCK LODE MINES.

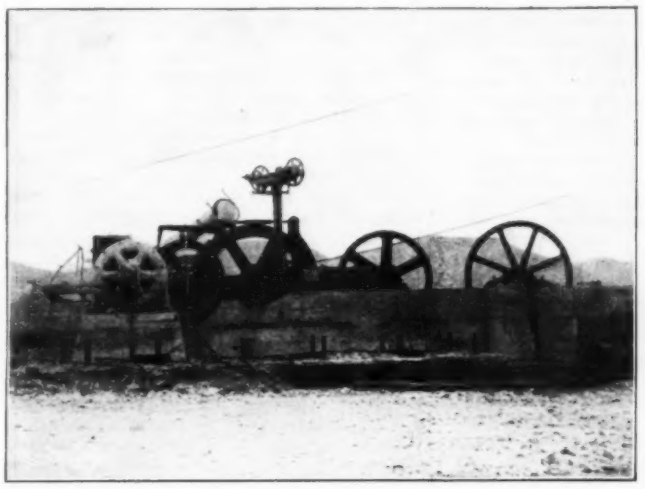
TRUCKEE RIVER POWER STATION AND PIPE LINE.

wire system, except in the Gould & Curry mine, where it is 110 volts.

The ventilation in the mines is of the best, as it must be, owing to the excessive heat and saturation from hot water. Most of the ventilation is of the natural type through various shafts on the different levels. The cold air is forced by electric fans to the different headings and stations.

The electric hoisting engines were designed by Mr. Leon Hall.

The reason for installing the Reidler pumps at the C. & C. shaft in 1902 was the inability to go any farther than 450 feet below the Sutro tunnel level with the power from the hydraulic water supply for the hydraulic elevators, which proved most practical sinking pumps. Although the efficiency is only 25 per cent, the cost of repairs is small, and this type of sinking pump is fully as reliable as any other appliance for this purpose.



200-HORSE-POWER ELECTRIC HOIST AT C. & C. SHAFT.

THE BETCHER MINE.

The Reidler electric pumping plant handles not only the mine water, but also the pressure water when the hydraulic elevators are used for sinking. However, when the shaft is free from water another pumping plant is to be placed at the 2,550-foot level, abandoning entirely the use of the hydraulic elevators.

The Reidler pumps are of the mechanically-operated valve type, and run at 110 revolutions per minute. This gear accomplished its object for high speed when first introduced, but, of those pumps that have been fitted with it, in many instances the positive valve gear has been removed, and the pumps have been operated with equally as good success without the gear. An instance of this is a pumping engine designed by the writer having positively closed valves, and running at a speed of 600 feet a minute, and from which the gear was removed for an experiment, to determine the capability of the engine running at the same rate of speed without the positive valve gear. Since the removal of the valve gear, the pump has been running three years with a very slight alteration in the arrangement of the valves themselves. The results have conclusively proved that high-speed pumps do not require positively closed valves, and that such valves cannot be operated at more than 130 to 150 revolutions, while properly constructed poppet valves are operating at as high as 300 revolutions without showing the defects natural to poppet valves. Various engines have been designed by the writer, and are now running at 600 to 800 feet without a positive mechanism, showing that water hammer from backward flow at the end of the stroke, which causes valves to seat hard, can be removed without the application of mechanically-moved valves, if the pump is properly proportioned in relation to water spaces, air chambers, and passages. Some designers advocate mechanically closing both inlet and outlet valves, while others favor mechanical opening. Again, some constructors mechanically operate but one set of valves. Such mechanisms are useless, and lead only to trouble and expense. Simplicity, as far as possible, is a desirable feature in all constructions.

In determining the type and design for the Ward shaft, the association was able to select the plant from the best types of pumping machinery in the world, and to consider the electric motor and pumping engine as a whole unit. It is a well-known fact that motors designed for such slow speeds as 100 revolutions will give a very low power factor, and that one of the same capacity running at 200 revolutions would give about 15 to 20 per cent better results as regards the amount of power saved at the generating station and the reduced cost for operating, and on this basis high-speed 200-revolution pumps without mechanically-operated valves were selected.

The International Steam Pump Company was represented by Messrs. Charles C. Moore & Co., engineers, its Pacific Coast agents, and Mr. Carl George P. de Laval, who came to Virginia City especially to carefully investigate the situation at the Comstock lode.

Mr. Leon H. Hall, chief engineer and superintendent for the Ward Shaft Association, conducted negotiations for the last-named association. The contract calls for two first-motion electrically-driven pumps, each of the units to have capacity for lifting 1,600 gallons of water per minute against a pressure equivalent to a height of 1,500 feet, or from the 3,000-foot level up to the level of the south lateral branch of the Sutro tunnel.

Each pump is to be driven by an 800-horse-power slow-speed induction motor. The contract includes column pipe, traveling crane for the pumping station, automatic oil system, a small air compressor for filling the air chambers, a small vacuum pump operated by compressed air for discharging air from the suction chamber, all the piping, valves of every description for completing the installation, and a complete set of duplicate parts of the pump.

It is intended to install a temporary drainage plant at the Ward shaft, first using an air lift to lower the water to the 1,800-foot level, and thence down to the 2,500-foot level without other pumps. The present bottom of the shaft is at the 2,500-foot level, and when that point is reached the shaft will be sunk through the solid rock to the 3,000-foot level, where the permanent pumps just contracted for will be installed.

Pumps of this type are built in capacities from 200 to 4,000 gallons per minute and for heads from 100 to 2,000 feet. The speed is 300 revolutions per minute, the efficiency of the pump alone, 95 per cent, of the motor, 92 per cent, and the combined efficiency, 85 per cent. The entire machine is self-contained, is mounted on a rigid box-girder frame, and occupies a relatively small space. It contains many novel features of construction, and the most careful attention has been given to the design of the internal parts as well as to the running parts and oiling devices. Its operation is practically noiseless under all conditions, and unaccompanied by the slightest shock or heating. The weight of both pumps for the Ward shaft and their motors is about 600,000 pounds, which may be interesting for comparison with the older pumps at the Comstock.

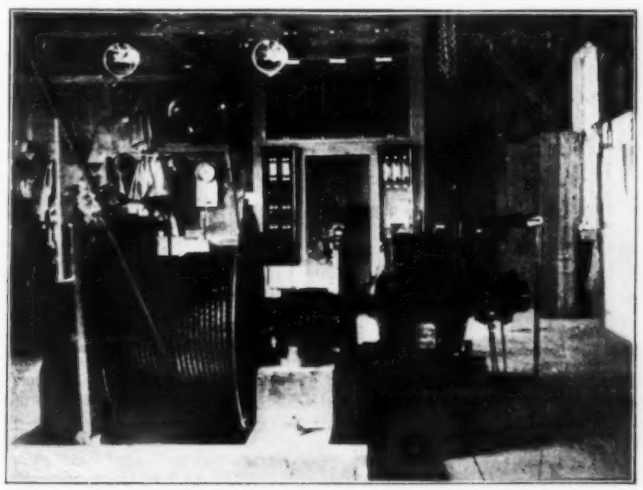
The Ward shaft electric pumps will have a capacity of 3,200 gallons against 1,500-foot head, and will cost $80,000. The Mexican Union pumping engine is a Cornish type compound, condensing, flywheel, Leavitt arrangement of cylinders, with a flywheel 36 feet in diameter, which, with its shaft alone, weighs 208,700 pounds. The high-pressure cylinder is 64 inches in diameter by 6 feet 9 inches stroke, and the low-pressure cylinder 100 inches in diameter by 8 feet 6 inches stroke. The nominal stroke of the pump is 10 feet. This engine was constructed in 1880, with a double line of 14-inch plunger pumps, discharging into the Sutro tunnel. Later the 14-inch pumps were replaced by 17-inch, and additional 18-inch pump rods were added, about 1,000 feet long. The pump rods, from the top bob to the 2,700-foot level, were 2,618 feet long. The total weight of moving parts was 1,620,500 pounds. The total lift of water was 1,180 feet to Sutro tunnel from the 2,700-foot level station. Due to the great length of pump rods, the effective stroke of the plungers was reduced from the surface stroke of 10 feet to an actual stroke of 9.7 feet.

The Cholliar, Norcross, Savage, Belcher, and Overman pumping engines were all of the compound, vertical, condensing, Davy type. The high-pressure cylinders were 32 inches in diameter, the stroke 10 feet 9 inches, and the low-pressure cylinders 65 inches in diameter and 8 feet stroke. No flywheels are used on this type, and the strokes are variable, as in any direct-acting pumping engine. These pumps force water from the 3,180-foot level to the Sutro tunnel, 1,570 feet. The total weight of the moving parts is 1,437,900 pounds.

In the underground station cuts at the 2,400, 2,600, and 3,000-foot levels, hydraulic pumping engines were used. The ratio of power plungers to pump plungers was proportioned so that the pumps could make six to seven strokes per minute.

In the Yellow Jacket shaft a pump was installed in 1880, which at that time was considered the best of any. The type of engine was a horizontal compound flywheel design, the high-pressure cylinder being 31 inches in diameter; the low-pressure cylinder, 62 inches in diameter; and the stroke, 12 feet. The balance bob was so constructed that the pump cylinders would receive a 10-foot stroke. This pumping engine took water from the 3,000-foot level, pumping it direct

THE YELLOW JACKET MINE.



ELECTRIC HOIST AT THE SIERRA NEVADA MINE.

PUMPING THE COMSTOCK LODE MINES.

to the surface, having a total length of pump rods of 3,055 feet. The weight of the moving parts was 1,510,400 pounds, and the engine made 5½ revolutions when pumping 432 gallons. An accident occurred to this engine, causing it to be closed down until the Sutro tunnel was completed, when it was replaced by a double line of pumps raising the water 1,516 feet to the Sutro tunnel and pumping 700 gallons per minute. About a month later a heavy flow of water from the 2,700-foot level of Exchequer Mine was encountered, flooding all the low levels. The pump was speeded up to its utmost capacity, 750 gallons per minute, but the water still gained and the pump was not able to hold it, nor could any other means at hand control the water. It was then stopped entirely and for good.

In the Ophir Mine the horizontal geared type of engine was used, the steam cylinder being 24 inches in diameter, with 5-foot stroke, and the pump being fitted with two flywheels. The pump stroke was at the surface 8 feet, and 7.7 feet below. The total length of the pump rods (partly on the incline) was 3,273 feet, the weight of moving parts, 1,067,500 pounds, and the water was pumped 900 feet to the Sutro tunnel, discharging 280 gallons per minute.

At the Consolidated California shaft the engine was of the Davy differential type, the high-pressure cylinder being 24 inches in diameter, the low-pressure cylinder 40 inches in diameter, with an 8-foot stroke, and 7-foot stroke for the pumps. The pumps could furnish 500 gallons per minute, and the weight of the moving parts was 860,000 pounds, with 2,150 feet of pump rods. These pumping engines cost, without foundations and installation, $1,300,000, giving maximum capacity for all of 5,400 gallons to an average height of 1,152 feet. The average cost for operating was about $34 per indicated horse-power per month. The total amount of water pumped was 5,040 gallons to an average head of 1,074 feet, with a total indicated horse-power of 1,703. The total cost per month was $58,120, or $697,440 per year, not including repairs, like a broken bob, wheels, plates, rods, plungers, etc. The hydraulic pumps handled 2,128 gallons per minute, and the Cornish 2,912 gallons, requiring about 2.7 miles of rods, which, together with all other moving parts, came to the grand total of 6,496,400 pounds of reciprocating details requiring to be started and stopped nine times every minute. It therefore required 2,230 pounds of moving parts for every gallon pumped. These figures are given for comparison with modern high-speed engines with small parts of light weight, as there are no heavy moving parts in directly-connected pumping engines, which give at once the most flexible system, accommodating themselves to any size of installation. Great weights in motion limit speed, and the strength of materials is soon exceeded, causing breakdowns and repairs. The old Comstock pumps could not be increased in capacity, as extra weight brought reduction of speed, as was shown at the Mexican Union, where the speed had to be reduced to about four revolutions per minute, on account of overstraining the rods, which were of 18 inches x 18 inches Oregon pine and 2,618 feet in length. Owing to the extreme hot water (170 deg.) and the saturated atmosphere of the shafts, the machinery and parts had to be constantly lubricated to an excessive extent, requiring careful watching for rotting of pump rods, rusting of wrought parts, and destruction. The cost of maintenance and power was enormous, and could not continue with the advent of new methods and devices and the demands of shareholders for more dividends. When the C. & C. electric pumps were started a new era dawned upon the Comstock lode, which will be followed by the installation of the permanent Knowles electric Express pumping engines just contracted for, draining the group of the middle mines upon the Comstock lode to a depth of 3,000 feet through the Ward shaft.

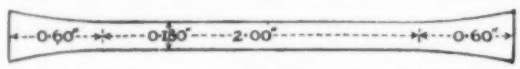
The awakening of Comstock is now a matter of fact; and if statistics are to be relied upon, the mineral deposits of this famous and marvelous camp have not yet been uncovered, many a fortune is still in store for our children, and history will be written of soul-stirring events. Again the rugged slopes of Mt. Davidson will be clustered by mines, with Virginia City thriving and prospering under permanent conditions. The only hindrance to progress has been the water, a problem which is now solved.

THE EFFECT OF LIQUID AIR TEMPERATURES ON THE MECHANICAL AND OTHER PROPERTIES OF IRON AND ITS ALLOYS.*

By Sir James Dewar, F.R.S., Hon. M.I.C.E., and Robert Asholt Hadfield, M.I.C.E., President-elect Iron and Steel Institute.

As many iron alloys have shown anomalous results in their physical behavior at ordinary temperatures, it became advisable to ascertain the exact effect of very low temperatures upon such bodies, and, accordingly, a series of tests were carried out on standard iron and iron alloyed with other elements, the specimens being selected from a large collection made by one of the authors, which is located at the Hecla Works, Sheffield. In the course of the inquiry some five hundred specimens have been examined, and the detailed description of each test will appear later on in a special monograph. In the meantime the more important results are submitted to the Royal Society.

For the purpose of the experiments, the irons were taken in the form of forged bars, and the iron alloys in the form of cast ingots 2¼ inches square. They were then carefully heated to the required forging temperatures, and reduced to rods ¼-inch diameter, and from these rods finished test-bars 0.180 inch diameter were accurately machined to the following sketch:



The bars were then forwarded to the Royal Institution Laboratory, and there tested in a small hydraulic testing machine, similar in principle to that described in Proceedings of the Royal Institution, 1894, to which the necessary arrangements could be applied for breaking the specimens while immersed in liquid air.

The present research confirms, in a larger field, the conclusions set forth in the discourse of one of the authors at the Royal Institution, in 1894, on the "Scientific Uses of Liquid Air," in which the results of tests on metallic wires and cast metals at low temperatures were discussed. The results of the present series of tests corroborate the inference previously drawn, viz., that all common metals and alloys increase in tenacity at low temperatures, and this whether the ductility increases or decreases, and, further, that the increase of tenacity is solely due to the low temperature, and persists only during its continuance.

The Results of Low Temperatures on Irons.—The first specimen examined in this class was Swedish charcoal iron, this material in its composition most nearly approaching that of pure iron. The analysis of this specimen gave C 0.045, Si 0.07, S 0.005, P 0.004, Mn trace, Fe 99.82 per cent. This iron, after careful annealing, gave 20 tons per square inch tenacity and 20 per cent elongation at normal temperature; after cooling in liquid air the tenacity rose to 38 tons, with substantially no elongation. Another specimen, after being quenched at 950 deg. C., and again at 600 deg. C. in water, showed similar results in liquid air. Two other specimens in the unannealed condition, and one after special heat treatment, showed similar properties. Specimens immersed in liquid air and allowed to return to the normal temperature before testing, showed almost exactly the same tenacity and elongation as before cooling, showing that the brittleness is entirely a function of temperature.

Several specimens were then quenched from 600 deg. C., 800 deg. C., and 950 deg. C. in liquid air, and allowed to return to the normal temperature before testing. It might have been expected that with this extraordinary chilling a considerable hardening effect would have been noticed, but singular to say, while the tenacity is practically the same in each case, the ductility is improved rather than reduced. It may be mentioned that the specimens quenched from high temperatures in liquid air remained red-hot in the liquid air much longer than would have been expected. In order to determine the hardness of these Swedish charcoal irons, a series of tests were carried out by the Brinell ball test, which showed that the hardness is increased nearly 200 per cent by quenching in liquid air. The specimens, though no doubt much stiffer than at normal temperature, could be readily filed at —182 deg. C. Magnetic tests also showed that no marked change takes place at low temperature as regards this quality.

In order to determine whether there is a critical point where the abnormal rise in tenacity and loss of ductility occurred, four specimens were tested at + 18 deg. C., —80 deg. C., —100 deg. C., and —193 deg. C. respectively. The results clearly show that there is no critical point, i. e., gradual decrease in temperature is accompanied by gradual increase in tenacity.

Other irons tested were L.S.S. Swedish iron, English Bowling, and Cooke iron, all showing increase in tenacity and corresponding decrease in ductility upon quenching in liquid air.

The next class are Iron-Carbon Alloys. This class is of special interest and importance, as upon the various percentages of carbon present in steel depend chiefly its physical properties. The specimen in which manganese is absent, or present in only very small quantities (C 0.14, Si 0.08, Mn 0.07 per cent), represents very mild or soft steel; it enables a comparison to be drawn between the Swedish charcoal iron, previously described, and soft steel. In the case of this specimen the tenacity was nearly trebled, but it is apparently more ductile than Swedish charcoal iron. A specimen containing C 0.78 per cent showed a considerable rise in tenacity in liquid air, the ductility being reduced to practically nil. A specimen of the same material was also submitted to the liquid air temperature, and allowed to return to normal temperature before testing; it showed a similar result to the original specimen not so treated.

It may, therefore, be said that the effect produced by liquid air is of a physical and temporary character. Other specimens, viz., Nos. 115 (C 0.83, Mn 0.25 per cent), 9 (C 0.85, Mn 0.32 per cent), 10 (C 0.09, Mn 0.32 per cent), 13 (C 1.23, Mn 0.14 per cent) showed the usual behavior at liquid air temperature. Specimens of No. 115 (C 0.83 per cent) were then quenched in liquid air from 700 deg. C. and 750 deg. C. respectively, and tested at normal temperature. As with the Swedish charcoal iron, the quenching from these comparatively high points has not produced the effect that might be expected; in fact, instead of the ductility being reduced, it is now quite considerable, viz., 13 per cent from the 700 deg. C. and 8 per cent from the 750 deg. C. Specimens of No. 13 (C 1.23 per cent) also showed the same singular effects after quenching from 700 deg. C. and 750 deg. C. in liquid air. It is certainly most remarkable that a specimen containing 1¼ per cent C, suddenly lowered 930 deg. C., is so little injured as regards ductility. If these specimens had been quenched from the same condition in ordinary water or oil, they would have been unfilable and of extraordinary hardness. These specimens were as magnetic at —182 deg. C. as at normal temperature, and readily filable.

In connection with this series, specimens were also taken of various iron-carbon alloys in which the Mn percentage was higher than in the preceding specimens, e. g., Test No. 110 (C 0.19, Mn 0.52 per cent), 1 (C 0.20, Mn 0.50 per cent), 2 (C 0.50, Mn 1.00 per cent), 3 (C 0.58, Mn 0.58 per cent), 5 (C 0.75, Mn 1.00 per cent), 11 (C 0.05, Mn 0.58 per cent), 12 (C 0.20, Mn 0.62 per cent), 31 (C 0.68, Mn 1.11 per cent). All these specimens showed the usual rise in tenacity and fall in ductility, and although Specimen No. 31 is of abnormally high carbon, yet this does not appear to have interfered with the ordinary effect of the liquid air treatment. In the case of Test No. 1, after quenching specimens of the same material in liquid air from 700 deg. C. and 750 deg. C., the same peculiar behavior was noticed as previously described, i. e., considerable increase in ductility.

Having now dealt with the iron-carbon alloys, the various other alloys may be dealt with:

Iron and Silicon Iron and Aluminium Iron and Tungsten Iron and Chromium Iron and Copper	Specimens were tested representing all these alloys, but the results do not call for any special comment, the usual increase in tenacity and fall in ductility being noticeable at low temperature.

Iron and Nickel.—Specimen No. 45 (C 0.26, Ni 0.58 per cent). Although the liquid air doubles the tenacity, probably owing to the lower carbon and the presence of nickel, the elongation is not reduced to the extent noticed in previous specimens. This is important, and gives material proof that the brittleness of iron at low temperatures can be modified by another element, provided the carbon is not present in any considerable percentage. In another specimen, No. 46 (C 0.14, Ni 1.92 per cent), the nickel appears to vigorously assert itself, as the ductility at —182 deg. C. only decreases from 20—12 per cent, the tenacity increasing from 34—59 tons. In Specimens Nos. 49 (C 0.19, Ni 3.82 per cent) and 50 (C 0.18, Ni 11.39 per cent), the remarkable effect of nickel is noticeable, as, while the tenacity rises considerably in both cases, the ductility remains practically unaltered. The tenacity rose in a further specimen, No. 54 (C 0.16, Ni 24.51 per cent), in which the nickel is very high, from 90—118 tons at —182 deg. C., the ductility being only reduced from 12—10 per cent. The specimens were non-magnetic both at normal and at liquid air temperature. The same material showed an increase of from 306—524 in hardness under the liquid air treatment.

Iron and Manganese.—These form an important class. The peculiar alloy of iron and manganese known as "manganese steel" is non-magnetic, and it is possible to produce similar alloys of iron and manganese even when the former element is present in as high a proportion as 87—88 per cent. Excellent results as regards physical properties can be obtained upon exceeding 1¼ and up to 2¼ per cent, provided the carbon is low. From about 3—7 per cent the material is comparatively brittle, even with low carbon. Upon exceeding 7 per cent the material now known as "Era" manganese steel is formed, and continues up to 17 or 18 per cent. Manganese steel proper is the alloy containing 11—15 per cent of manganese with carbon varying from 0.80—1.40 per cent.

We will deal first with manganese steels having low carbon, i. e., under 0.30 per cent. Test No. 14 (C 0.08, Mn 3.50 per cent), the usual rise in tenacity and loss in ductility occurs at —182 deg. C., and on the specimen being allowed to return to normal temperature it does not appear to be injured in any way. Samples Nos. 15, 16, and 17 (Mn varying from 5.40—15.28 per cent), which are extremely brittle at normal temperature, show very little modification at the low temperature.

Dealing now with alloys having higher percentages of carbon, several specimens tested with Mn ranging from 2.23 to 11.53 per cent, with carbon increasing proportionately from 0.41—1.66 per cent, showed normal behavior at low temperature. An interesting specimen, No. 26 (C 0.23, Mn 12.64 per cent), was examined, representing a normal "Hadfield manganese steel." At normal temperature this gave 56 tons tenacity, with the high elongation of 30 per cent, and after immersion in liquid air showed a slight rise in tenacity, the elongation, however, falling to 2½ per cent, the low temperature thus entirely de-toughening the material. This result is somewhat unexpected, as it might have been anticipated that the great ductility of this material at normal temperature would not have been interfered with to any great extent at the low temperature. In the ordinary treatment of Mn steel for toughening, the sudden drop in temperature is about 1000 deg. C., and in the liquid air only 200 deg. C. A repetition test, No. 26A, gave a similar result, the tenacity at normal temperature being 65 tons, with 40 per cent elongation, while at —182 deg. C. the ductility dropped to nil, the tenacity remaining the same, viz., 64 tons.* Similar specimens of this steel cooled down and allowed to return to normal temperature again exhibited the usual extraordinary toughness of the material, thus showing that the de-toughening or embrittling action is only temporary, as with the Swedish charcoal iron and ordinary steel specimens.

It is certainly curious to find that a specimen of steel,

* A paper read before the Royal Society.

* It is very extraordinary that the metal iron, no matter what its treatment, never becomes so ductile as the treated and quenched manganese steel—mainly composed of iron—with an original ductility of 40 per cent.

which only a few moments before would break in the easiest manner, can again be bent double. This is produced by a change in temperature conditions of about 200 deg. C. These results also show that manganese steel, notwithstanding its many peculiarities, in this respect falls into line with and is subject to the same laws as iron and ordinary steels. It is therefore all the more curious that the iron-nickel-manganese alloy (1414n) described later, entirely differs in this respect, where the effect of low temperature is not only nil, but there is a positive increase in ductility. The Ball tests on specimen No. 26 show an increase in hardness at —182 deg. C. of 70 per cent, viz., from 205 to 372. Three other specimens, Nos. 26 *E*, *F*, and *G*, are also interesting as showing the effect of quenching upon Mn steel, from temperatures of 605 deg., 800 deg., and 950 deg. C. in liquid air, the tests being then carried out at normal temperatures. The specimens *E* and *F* give similar results to those that would be obtained by quenching in ordinary cold water at 600 deg. and 800 deg. C., i. e., little or no increase in ductility. On the other hand, in specimen 26 *G*, quenched from 950 deg. C., there is no doubt the result obtained, 66 tons tenacity with 38 per cent elongation, is excellent, but it is not any better than can be obtained by quenching in water at 15 deg. C. It is important to here mention that the three specimens, *E*, *F*, and *G*, were all non-magnetic at —182 deg. C., showing that there is no change in the magnetic properties of manganese steel at low temperatures. This experiment finally settles quite a number of misunderstandings in metallurgical literature which have arisen on this subject, namely, that at no range of increase or decrease in temperature (provided this is not, as regards high temperature, sustained for any length of time) does any marked change in magnetic property occur in manganese steel.

The effect of low temperature on Iron alloyed wtih Two other Main Elements. Taking first the alloys of Iron, Nickel, and Chromium. Tests Nos. 78 (C 0.25, Cr 0.64, Ni 2.67 per cent) and 81 (C 0.89, Cr 2.00, Ni 1.92 per cent).—In the first instance in the presence of low carbon the nickel shows its toughening influence, as at —182 deg. C. the tenacity rises from 38 to 61 tons, the elongation only falling from 20—17 per cent. In the latter specimen the effects of the nickel are not so apparent owing to the higher carbon, but the elongation does not entirely disappear. Another specimen of this latter material after quenching in oil at 760 deg. C., and then water at 650 deg. C., showed an increase in tenacity at —182 deg. C. of from 81—105 tons, the elongation being, however, reduced from 7½ per cent to nil. The embrittling influence of the carbon is seen in both instances. In the next specimen, No. 79 (C 0.31, Cr 1.80, Ni 2.60 per cent), the ductility is not affected, remaining at 15 per cent. Notwithstanding the considerable presence of chromium, the nickel asserts itself in this specimen, the tenacity rising from 49—79 tons. A similar result was also noticeable in specimen No. 107 (C 0.17, Cr 1.55, Ni 3.02 per cent), the tenacity rising to 59 tons, and the ductility dropping only from 25—20 per cent. Test No. 80 (C 0.64, Cr 2.01, Ni 12.24 per cent).—In this specimen the very high tenacity at the normal temperature (115 tons) does not appear to be affected by the liquid air; in other words, a steel having high tenacity at normal temperature is practically unaffected by liquid air.

Iron, Nickel, and Silicon Iron, Manganese, and Chromium Iron, Manganese, and Silicon Iron, Chromium, and Aluminium Iron, Chromium, Silicon Iron, Chromium, Copper Iron, Chromium, and Tungsten	Tests were carried out in liquid air on specimens representing these alloys, but the results do not call for any special comment, in all cases the specimens behaving in the normal manner, i. e., showing increase in tenacity, and decrease in ductility in liquid air.

Iron, Manganese, Copper.—Test No. 19 (C 0.25, Mn 2.01, Cu 1.39 per cent) shows a remarkable rise in tenacity, the elongation remaining unaffected by the low temperature. It is remarkable that the copper, which is present only to the extent of 1½ per cent, absolutely neutralizes what would be the action of manganese, which clearly produces brittleness and hardness at low temperatures.

Iron, Cobalt, Manganese, Silicon Iron, Chromium, Manganese, Silicon Iron, Nickel, Manganese, Aluminium	Tests were carried out on specimens representing these alloys, but the results do not call for any special comment.

Iron, Nickel, and Manganese.—In this class a number of specially interesting results were obtained. There is an important alloy, No. 1109b (C 0.60, Mn 5.04, Ni 14.55 per cent), including two elements in exactly the same proportions, which, if added separately to iron, would cause extreme brittleness. Most singular to say, this double combination now confers extraordinary toughness. This alloy is probably the most ductile form of iron alloy known, in several cases an elongation of no less than 75 per cent having been obtained at normal temperature. Taking the first specimen, No. 60, under liquid air treatment, this material drops in elongation from 70—25 per cent, this remaining ductility even now being very great. This is the first specimen met with in which the ductility remains comparatively high. A further test carried out on the same steel shows a similar result. It may be mentioned that the magnetic qualities of the specimen remained unchanged at —182 deg. C. 1109b may be termed almost non-magnetic, though not so much so as manganese steel. 1109b is much more sensitive to magnetic changes by temperature, though to an ordinary magnetic test it appears inert.

The next specimen, No. 61 (C 1.00, Mn 6.05, Ni 7.91 per cent), shows a further increase in nickel percentage, and this is clearly the factor in preventing loss of ductility at —182 deg. C., the ductility only decreasing from 57—42 per cent. Another specimen taken, No. 114 (C 1.18, Mn 6.05, Ni 24.30 per cent) shows a still further increase in percentage of nickel. For the first time in this series of tests there is now met with a specimen in which there is an actual rise in ductility at —182 deg. C. The tenacity now rises from 51—84 tons, and the ductility from 60—67 per cent. This is remarkable. It is curious that the considerable percentage of manganese does not interfere with the toughening of the iron, of which there is 68 per cent. In any case it cannot be claimed that manganese confers this, as it must be remembered that a similar percentage of manganese in an iron alloy containing no nickel shows remarkable brittleness either at normal or low temperature. Nor does an iron alloy containing a similar high percentage of nickel, and no manganese, show much ductility. In face of these apparent anomalies it is difficult to offer a satisfactory explanation of the remarkable effects noticed. A repetition of the above test showed even more remarkable results, the ductility rising from 42—57 per cent.

The liquid air experiments on this series (iron, nickel, manganese) bring out in a much clearer manner than any other tests have yet done, the remarkable toughness and ductility of the iron alloys containing 6 per cent Mn and 14—24 per cent nickel. They show what an extraordinary molecular combination has been produced. In other words, these particular iron alloys have almost non-magnetic properties, possess the highest electrical resistance of any known alloy, and also represent the most ductile iron alloy yet known.

The Concluding Group includes Metals and Miscellaneous Alloys.—The first specimen taken in this group was No. 120, forged nickel (C 0.09, Ni 99.27 per cent), representing an excellent quality of commercial nickel. This was tested in the forged condition, and in liquid air the tenacity was increased from 29—46 tons, and ductility from 43—51 per cent. This may be considered a remarkable result, and probably explains why in iron-nickel and iron-nickel-manganese alloys the presence of nickel (provided the carbon is low) prevents low temperature injuring iron. It is difficult to explain why this should be so, in view of the similar position of these two elements in the chemical classification of the elements.

Although no absolutely pure specimen of the metal manganese is yet available, that containing about 98 per cent shows comparative brittleness, and in this respect, therefore, entirely differs from the metal nickel. This, to some extent, explains why nickel-iron alloys are remarkably tough, but still leaves unsolved why manganese steel which contains 12 per cent of Mn, is so extraordinarily tough when alloyed with iron and some carbon, and quenched from high temperatures.

Test No. 131 (copper 99 per cent) shows that while the results obtained from this metal resemble nickel, the tenacity being increased, it is to a much less degree, the ductility not being materially altered.

It is curious to find that by chilling down the metals iron, nickel, and copper to —182 deg. C. their absolute and ultimate—if the terms may be allowed—qualities are shown more truly than at the normal temperature. The effects here noticed also explain in a more satisfactory manner than has yet been possible, why nickel is so valuable in nickel-iron alloys; that is, it tends to counteract the constant tendency of the sensitive metal, iron, to become embrittled on the slightest provocation. If this research reveals this one important fact, it will have well repaid the labor.

From the results it would seem to be indicated that copper might be a useful metal to alloy with iron. There are, however, difficulties in the way of this, at any rate as regards forged metal, as copper-iron alloys containing no manganese are considerably red-short, and cannot be readily manipulated. For some reason not yet explained it also does not alloy well with iron, but this may be a question of temperature effect at fusion point. At any rate, these experiments are suggestive for further research and investigation.

In the case of aluminium, Test No. 113 (Al 99.50 per cent), the metal shows a remarkable increase in tenacity, viz., 8 to 15 tons, the elongation being nearly quadrupled, viz., from 7 to 27 per cent. Singularly enough, when alloyed with iron, such increases in both tenacity and ductility are not noticed; in fact, a contrary effect was produced.

Specimens of cupro-nickel (Cu 95, Ni 4.85 per cent) and Bull's metal showed only slight changes at low temperature, while specimens of delta metal and manganese copper showed a rise in tenacity and ductility.

Various experiments carried out in connection with this research deal with contraction, electrical properties, micro-structure, magnetic and brittleness tests, all of which will be included in the special monograph.

General Conclusions.

It is clear that as regards iron and iron alloys, with, however, certain exceptions, the effect of low temperature is to increase in a remarkable degree its maximum tensile stress, and to reduce its ductility to practically nothing. These changes take place to the same extent, and this is very curious in the softest wrought iron, as represented by the specimens S.C.I. (Swedish charcoal iron), L.S.S. (the famous Swedish melting iron), and also English wrought iron, and in carbon steel samples from 0.10 to 0.20 per cent to the high percentages, such as 1.25 or 1.50 per cent. Thus, the absence or presence of carbon in ordinary carbon steel, in which other special elements are not present, seems to have but little influence. That there is no error in this statement is proved, independently of the tensile tests, by the fact that several bars of the S.C.I., and mild steel specimens, were submitted to the low temperature test, and tested by hammer immediately after being immersed. In all cases they exhibited great brittleness, breaking off instantly upon being struck. Further confirmation is obtained by the Brinell hardness ball test, under which test the hardness number of the S.C.I. increased at —182 deg. C. from 90 to 266, or about equal to the hardness of 0.80 per cent carbon steel at normal temperature. This seems almost incredible when it is remembered that the S.C.I. shows by analysis 99.88 per cent of iron, and has only 20—22 tons tenacity, with 25.30 per cent elongation.

The importance of the discovery of the toughening effect of nickel upon iron at low temperatures will be seen when it is understood that, while it has been well known that nickel in certain percentages produced important improvements in the qualities and properties of iron and steel alloys, no microscopical or chemical research work has yet proved why this came about. It seems clear that these experiments go a long way toward offering a satisfactory explanation. The experiments prove that the purest iron, as represented by the S.C.I. (containing 99.82 per cent iron), becomes brittle to an extraordinary degree under the influence of low temperatures; whereas nickel itself, tested under the same conditions, has improved rather than deteriorated, not only in tenacity, which iron also does, but in ductility, in which latter quality iron entirely breaks down. If nickel, therefore, is present in an iron alloy containing but little carbon, or comparatively low in that element, it acts as a preventive of brittleness, or is a very considerable modifier of that objectionable quality. It may be interesting to state that at ordinary temperatures the toughness or ductility of nickel is no greater than that of iron. For example, in comparative tensile tests made on nickel and pure iron, the ductility of iron was greater.

Iron to a more or less degree, at any rate in manufacturing operations, always seems to be endeavoring to wander out of the "paths" of ductility and toughness, and will assume its apparently brittle nature on the slightest provocation. It would appear, therefore, that iron, a cheap and convenient metal itself, must be permeated by some element that will mask or modify its properties. Until recently carbon was the only element known to modify the properties of iron; but, as will be seen in this research, this element, where great toughness is required, only helps to make matters worse. Fortunately for iron, however, its close companion, nickel, acts as a preventive in keeping it from wandering out of the narrow road of metallurgical rectitude, that is toughness and ductility. Why this should be so cannot at present be explained. Iron is a crystalline metal, whereas nickel appears to be much more amorphous; it is possible, therefore, that nickel tends to prevent iron crystallizing. This action of nickel is remarkable in certain of the alloy specimens, e. g., No. 114, which is an alloy of iron, carbon 1.18 per cent, nickel 24.30 per cent, and manganese 6.05 per cent. Here the ductility is extraordinary at not only normal but low temperatures, probably the highest known for any known iron alloy, and certainly for an alloy having such tenacity as 85 tons per square inch. There is still present in this alloy 68 per cent of iron, yet the tendency of the latter metal to become brittle is not only entirely checked at the low temperature, but the elongation, already so great, is considerably increased, viz., from 60 to 67½ per cent. There is also an increase of tenacity in both cases, viz., a rise from 10 to 38 per cent. Thus the nickel present causes the bar under high tension, and at —182 deg. C., to remain far more ductile than the very best ductile iron of one-third the tenacity. Although the action of nickel has been specially referred to, it must not be overlooked that in this alloy there is also present 6 per cent of manganese, which in its ordinary combination with iron, that is with no nickel present, would confer intense brittleness upon the iron and render it more brittle than if not present. This treble combination of nickel, manganese, and iron, appears to reverse all the known laws of iron alloys.

We have to thank the mechanician of the Davy-Faraday Laboratory, Mr. C. N. Cooke, for able assistance in the conduct of the experiments.

ALTERNATE-CURRENT ELECTROLYSIS.—A. Brochet and J. Petit have succeeded in analyzing certain organic acids by means of an alternating current, and have observed a high efficiency of the alternating current. They used a test tube containing about 150 cubic centimeters of solution, and ribbons of platinum as electrodes, the mean current density being 1 ampere per square centimeter. The solutions used included solutions of the formates of potassium and barium, and acetic and oxalic acids. With the potassium formate, the results are extremely variable, and the electrodes are rapidly covered with a light deposit of carbon. The efficiency rapidly diminishes, and it is necessary to make the measurements quickly, and to calcine the electrodes after each experiment. The carbon obtained does not adhere to the electrodes, but spreads through the liquid and gradually falls to the bottom. The gas developed is nearly pure hydrogen, with a very slight admixture of oxygen and carbonic acid. The efficiency is 80 to 90 per cent. The barium formate gives about 65 cubic centimeters per minute of a mixture of hydrogen and carbonic acid, the efficiency being about 75 per cent. There is practically no oxide of carbon dis-

engaged. The analysis is in every way similar to direct-current analysis.—Brochet and Petit, Comptes Rendus, February 13, 1905.

IMPROVED COASTING SLEDS.

THE "luge" is a small sled peculiar to the Grisons (Switzerland), which recalls the *schlittes* of the Vosges, and which up to the present has been steered by hand through the intermedium of short, iron-pointed sticks. The general extension of sports on hills prepared for coasting, in Europe, has placed the luge in the same category with the Canadian "toboggan," and, by combining these two apparatus, a type of sled has been devised that carries several persons instead of one, and that is provided with mechanical steering arrangements. To these new apparatus, which are very light (their weight being but 115 pounds), the name of "bob-sleds" has been applied. They accommodate four persons, are 12 feet in length, and have a tread of 12.5 inches.

We shall first describe the "Leysin bob-sleigh," the type that was first introduced, and then pass to the "Phenix," the invention of which is more recent, and the arrangement of which is not so well known.

The "Leysin" consists of two coupled toboggans, the first of which is the steering one. The seat bodies are fixed to the sleds by five springs (two on the front sled and three on the rear one), designed to deaden the shocks produced by low heaps of snow. They have no effect against such obstructions on the hills prepared for coasting ("Russian mountains," as they are called), and so, in order to attenuate the shocks, the sled is provided on each side with hand rails that permit the tobogganist to raise himself, just as the bicyclist raises himself on his pedals on rough places in the road. In order to make 50 and even more miles an hour, necessitated a sensitive and safe steering device. In descending a track about six feet in width at a speed of 75 feet a second, it would require a deviation of but 2.5 degrees of the extremity of the steering sled, situated 20 inches from the king bolt, to throw the sled out of the track in less than a second. The automobile steering hand-wheel, having appeared to be the proper apparatus to use, was tried and found to be efficient. This is of aluminium, and is fixed upon the same axis (steel tube) as a cast-iron pulley over which passes a twisted belt attached on each side of the steering sled in such a way that when the hand-wheel is turned to the right the pulley draws upon the belt and directs the first sled to the right around its king bolt, and *vice versa*. As the hand-wheel is placed in a nearly vertical and very low position, it provides the captain with a firm bearing point for preventing jolts, and actuating the brake by means of his foot. Immediately behind the steering wheel there is a double lever, which the captain shoves forward with his right or left foot, or both feet at once. This is connected by two regulatable steel wires with a double joint, which, fixed under the body of the rear seats, bears against two strong iron spurs that it forces into the snow.

The seat body is formed of frames composed of two pieces of ash of triangular section between which are stretched leather seats at a height of 6 inches above ground. Thus constructed, the "Leysin" won every race in which it took part. It was found, however, that the use of wood was objectionable, since it is impossible to make with it assemblages that withstand strong shocks, and to secure the steel runners firmly to it. Then again the brake obliged the captain to let go with one foot, and the hand-wheel required too great revolution in abrupt turns. Therefore, the "Phenix," which is entirely of steel, was constructed.

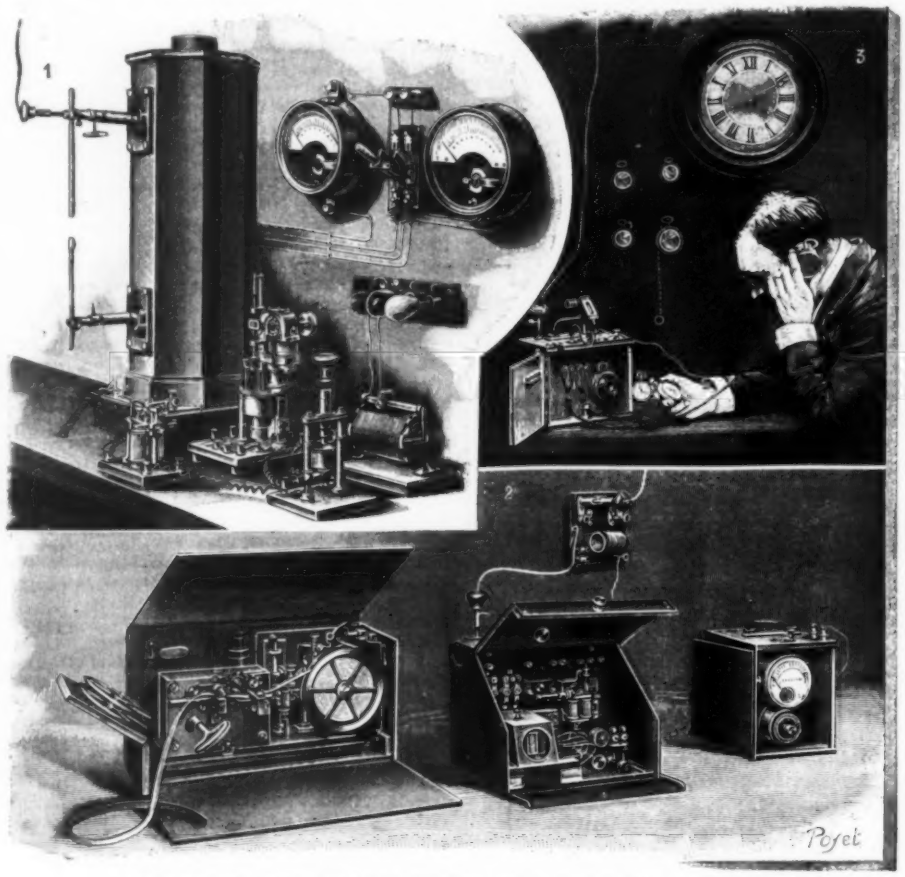
A frame about twenty-eight inches in width, formed of large steel tubes, constitutes a protective inclosure for the feet and legs of the tobogganists, and serves as a hand-rail. It is firmly connected with a second frame, which is of angle iron, and narrower, but of the same length, and situated 5.5 inches below the first, and 6 inches above the ground. This serves as a slide for the seats of the three tobogganists, and carries that of the captain. This frame, through the intermedium of special springs, rests upon two long and flexible sleds of which the runners are formed of a single bar of cast steel. The tread is 22 inches. These sleds are mounted upon a pivot, the first swinging in all directions and the second in a lengthwise direction solely.

In the "Leysin" the mounting of the sleds with respect to the seat platform permitted of but a slight swing for the purpose of riding the "waves" without plunging or plowing. The same inconvenience presented itself with springs of great flexion.

The "Phenix" is provided with springs of a single thick plate, and the runners are strongly curved, so as to adapt them better for high speeds. The steering wheel is placed a little higher, and the metallic cable that pulls the steering sled to the left or right passes over and is secured to an oval and eccentric drum. In this way, the lever arm of the axis of revolution of the drum is smaller when the sled is steered in a straight line, and requires no more than a third of a revolution of the steering wheel for an abrupt turn.

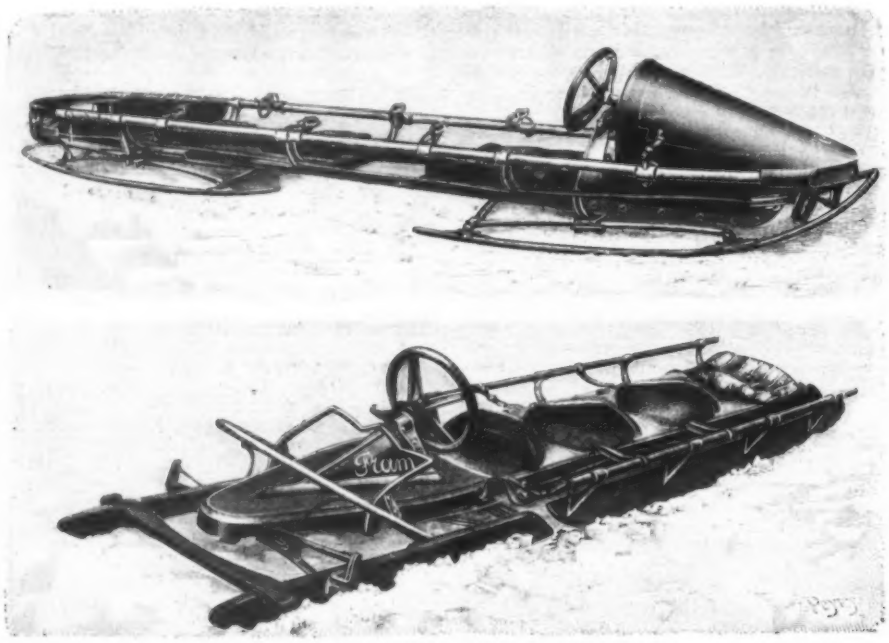
The brake has been so modified that the maneuvering pedal shall remain constantly under the captain's foot, and allow him to effect the braking by a simple motion thereof. The seats of the three tobogganists are mounted upon a strap stretched over a frame of steel tubes. They slide together, upon rollers, in the angle-iron frame.

Finally, for the purpose of interesting the tobogganists more in the outcome of the race, and in order to more quickly pass over level places or slight inclines, there is arranged under the steering sled what is called a "propeller"—a sort of wheel that takes a purchase on the snow, when need be, and is actuated by the tobogganists.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Nature.



APPARATUS FOR TRANSMITTING THE TIME TO A DISTANCE

1. Transmitting station. 2. Receiving apparatus. 3. Clock for regulating a watch by means of a receiver.



IMPROVED COASTING SLEDS.

DISTRIBUTION OF THE TIME BY WIRELESS TELEGRAPHY.

EVERYBODY knows how difficult it is to obtain the exact time. If, for example, we wish to control the running of a watch, we quickly see that we cannot place any reliance upon any regulator or public clock. Every clock marks a different hour, and it may be said that it is sometimes noon for several minutes in the various districts of Paris, and even of any city whatever of Europe. In order to obviate this state of things the idea has occurred in several European cities to connect the astronomical observatory electrically with the ward clocks. At Paris especially, clocks connected with the observatory, and giving the hour of the first meridian, have been installed for more than a quarter of a century. Their running is regulated by electricity, but the transmitting mechanism is such that a few teeth may escape and result in differences in the operation of the hands. The best thing to do would be to adopt one of these clocks and use it for judging of the deviations of a watch. Each clock individually operates well, but small differences may sometimes exist between several. Two electric circuits have been established at Paris that control the running of fifteen standard clocks; but this system, like that employed in other countries, is complex, quite costly, and in limited use. M. Bigourdan, of the Academy of Sciences, and astronomer at the Observatory, has thought of a much simpler solution of the problem, and has recourse to wireless telegraphy. In principle, a directing clock every second controls a relay that sends through space a signal that may be received everywhere, even in any apartment whatever. M. Bigourdan describes his system as follows: "The directing clock, installed in the Observatory, upon opening an electric contact every second, controls a relay which, in turn, sends a current into the primary circuit of an induction coil provided with an oscillator. The induced circuit of this coil thus furnishes an oscillating discharge of very short duration which occurs regularly every second. One of the poles of the fine wire of the coil is grounded, and the other is connected with an antenna a few yards in length. By means of this antenna, the sparks control receivers of electric waves at a distance, and thus all the receivers beat, at a nearly constant interval, every second of the directing clock."

M. Bigourdan, with the assistance of M. Ducretet, has tried two different receivers, the simpler of which

is the Popoff-Ducretet radio-telephone. In this is distinctly heard every second beaten by the directing clock. The second, which is an inscribing one, consists of an ordinary wireless telegraph receiving apparatus. In this, M. Bigourdan sometimes substitutes a chronograph with tape and pen for the Morse receiver. With this chronograph, which pays out about half an inch of tape a second, the signals obtained are distinct, and every hour can be taken with each of them within 2/100 or 3/100 of a second. Although the means employed in these experiments were very unpretentious, a very satisfactory transmission was obtained in a station one and a quarter miles distant, and a very much greater distance might certainly have been reached. Consequently, it follows from these experiments that, with slightly more expensive means, it would be possible to distribute the time in this way to every point of Paris, and even of the suburbs.

In order to number the minutes and seconds, it would be well to begin the emissions at the second-zero of each minute, and cause interruptions, say, every ten seconds. Moreover, there could be no error in the minute, since when the exact hour is wanted, there is generally available a chronometer that leaves no uncertainty of more than a few seconds. The precision required for current use does not exceed three or four seconds. Now, it is easy to keep the correction of a standard clock for distributing the time below such figures.

Wireless telegraphy waves, as we know, are propagated circularly, like the waves produced upon water into which a stone has been dropped. An impression is consequently made upon every receiver within a given radius. The time might be sent thus to dwellings. From the viewpoint of scientific researches, determination of longitude, and determination of gravity, the new system might render great services.—Translated from La Nature for SCIENTIFIC AMERICAN SUPPLEMENT.

RECENT EXPERIMENTS ON THE NATURE OF MAGNETISM.*

By EMILE GUARINI.

ALTHOUGH the magnet has been known from the remotest antiquity, the ideas that we hold as to the nature of the phenomena to which it gives rise are still vague, and the present theories as to magnetism do not appear as if they were definitive.

We shall not stop to rewrite, after so many others, the history of magnetism, of the compass, etc., but shall let it suffice to recall the fact that our conceptions and hypotheses on the subject of magnetism present numerous weak or obscure points, which too great an effort could not be made to elucidate, since the question here is not only one of pure speculative science, but also of general practical interest.

Herr Joannes Zacharias, the well-known German engineer, who has been occupying himself with this question for a quarter of a century, has recently made known the results, or at least some of the results, that he has obtained from the researches that he has pursued with an ardor and tenacity so much the more praiseworthy in that the only reward that he can hope to reap from his labors is honor.

Whether the ideas of Herr Zacharias are the most rational and accurate, whether his theories are those that most closely approach the truth, or that most simply and satisfactorily explain the properties of magnets, and of magnetic or diamagnetic bodies, we shall leave the reader to decide, if it be possible to pronounce judgment accurately from the data that the experimenter recently communicated to his fellow citizens in a lecture delivered at Kassel.

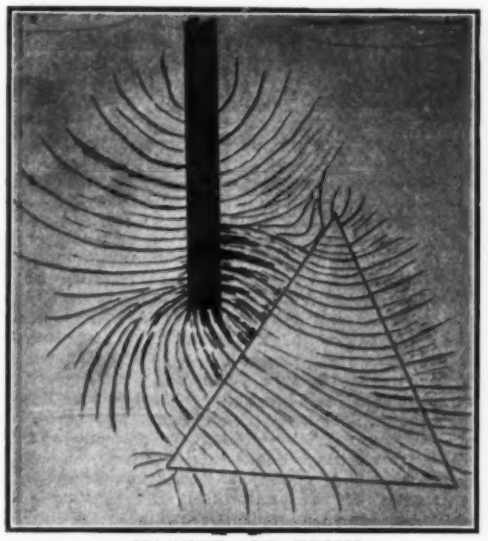
Herr Zacharias has endeavored to interpret what by common consent have been called the lines of magnetic force, and, in order to do this, has devoted himself to a persistent and unremitting study of the magnetic spectra of different forms of magnets, permanent as well as electric. Such attention, constantly bestowed for years upon the same subject, has given the German scientist an extraordinary lucidity of views and comprehension; and it would be committing an unpardonable mistake, we think, to reject the conclusion that he has drawn from his long work, and that he has summed up in the words, "Magnetism is light," simply because others have not immediately reached the same result.

Herr Zacharias's patience demands from the adversaries of his theories considerable reserve, for it is not lightly that he has expressed the ideas that subvert the hypotheses that have been held up to the present, for the want of better ones, moreover, and it is not lightly either that they should be rejected.

Herr Zacharias began the study of this exceedingly interesting question in 1880, at the instigation of Prof. Anderssohn. Two years later, he thought he was in a position to conclude that there was a similarity of the phenomena of attraction and repulsion between magnets to electric, calorific, and luminous phenomena, and to attribute them to the motion of molecules. Twenty years afterward he described some experiments that he had tried, and that in his opinion corroborated an assertion made by him in 1882 that "magnetism is based upon a pressure of the ether."

Controversies have already fortified Herr Zacharias's confidence in the accuracy of his hypotheses and impelled him to make more numerous and minuter researches, and these have finally led him to conclude, more precisely still, that magnetism is nothing more than a phenomenon identical with luminous phenomena.

Herr Zacharias's researches began with the aid of an electro-magnet with an external shell of iron. The experimenter soon satisfied himself that the opinion generally held as to two poles in the core and the iron shell was not justified. The considerable increase of power through the addition of the metallic covering around the winding, as well as the existence of lines of force in a vertical as well as in a horizontal direction, appeared at the outset as incontestable proofs of the inaccuracy of existing ideas.



MAGNET AND PRISM.

Numerous experiments performed with the most diverse forms of magnets soon led to a generalization of the preceding conclusion, viz., that the direction of the magnetic force depends solely upon the coils, the iron external to the latter playing no other part than that of a resistance.

It is erroneous to say that the iron "conducts" the "lines of force" well, and erroneous also to consider the armature of a magnet as becoming magnetized by induction; for such an armature, once again, behaves simply as a resistance.

It will perhaps prove astonishing, at first, to hear two things apparently so different as light and magnetism compared, although there is here but a new extension of the theories of Faraday and Maxwell. Experiment shows, nevertheless, that there is a similitude of causes between the two agents under consideration, and, moreover, a similitude with calorific and electric phenomena.

It ought not to be imagined that a comparison should be instituted between the magnetic pressure of ether and pure and simple hydraulic pressure. Much more than this, the magnetic phantom does not represent what is commonly called the "line of force." In Herr Zacharias's view, magnetization is not a state of matter, but a motion of molecules, as in electricity, light, and heat.

All the molecules of bodies are possessed of continual motion so long as the temperature does not reach absolute zero, and such motion is participated in by the ether, intermolecular as well as extramolecular. They react upon each other according to the laws of Newton and Coulomb, that is to say, proportionally to their masses, and in the inverse ratio of the square of their distance. To be brief, all bodies radiate around them with a motion that is invisible to us under ordinary circumstances, and which is made clear by producing visible displacement, only in case of interference, resonance, etc.

There are, then, not several forces, but one only, under the same form or under different ones; it is the "universal energy" that is transported by the ether. The law of Newton is absolutely general, and is applicable to the infinitely great as well as to the infinitely small. . . .

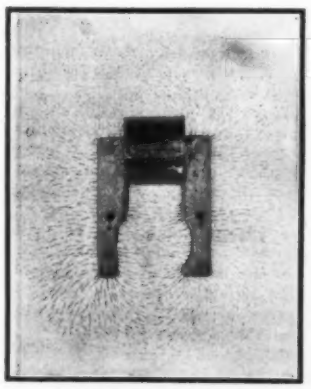
Let us consider a straight electro-magnet, and let us, by means of iron filings, make apparent to the eye the magnetic lines of force. If we somewhat attentively observe the iron filings, we shall readily ascertain the presence of a straight line in the prolongation of the axis of the core, and that from one part or another of this straight line other lines bend back and connect the poles. The curve of these is so much the more characteristic in proportion as the magneto-motive force developed in the winding is greater. In other words, the greater the number of ampere-turns the more extended will be the visible field.

We can and should, says Herr Zacharias, explain these phenomena by admitting that the electric motion that is produced in the coil and upon the core brings about a corresponding motion of the inter- and extramolecular ether, and from this there results the formation of a neutral zone in the median part, and centers of pressure toward the extremities. The movement of the magnetic field has the effect of introducing an ethereal vacuum into the core, and it is upon the extent of this vacuum that depends the power of the magnet. This vacuum, and consequently the force of magnetization, exists whatever be the direction of the motion; but the "polarity," that is to say, the distribution of the poles, to employ ordinary terms, depends upon the direction of the displacement. If the current is continuous, it will be invariable, and, if it is alternating, it will change direction alternately. If a straight magnet be brought near to a movable magnetized needle, there will occur phenomena of attraction and repulsion which will be shown by characteristic modifications of the field, and consequently of the magnetic flux.

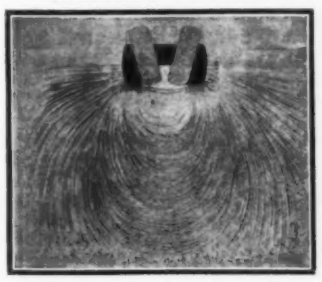
Other experiments show very well, also, the attraction and repulsion between a needle and a magnetized bar. Two revolving metallic balls, one of them suspended from a thread, repel each other. The operation can likewise be performed with small balls, without there being any contact, and with the interposition of a pane of glass.

In all the experiments performed by him, Herr Zacharias made it a point to take a faithful image of the object by photography and, upon studying the figures obtained, he came to the conclusion, as we have before stated, that the form of the core plays no part as regards the force of magnetization, and that the latter is not localized, as generally supposed, at the extremities of the bar.

Magnetism is a motion, and not a particular stable state. Such an assertion, which is quite easily admissible in the case of the electro-magnet, becomes less easy of acceptation when it is a question of the permanent magnet. Why should the latter persist in its attractive properties? How, through what cause, and by what force, is the special motion of the molecules kept up? It would be like seeking for the principle of life itself to approach this strange question. With Herr Zacharias, we think, nevertheless, that the permanent or natural magnet cannot differ from the electro-magnetic one. Without being able to give a complete explanation of its very essence, we compare the persistence of certain bodies in preserving the magnetization that



ELECTRO-MAGNET.



ELECTRO-MAGNET OF 20,000 AMPERE WINDING.

HERR ZACHARIAS AT WORK IN HIS STUDY.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

they have acquired, with that no less singular phenomenon called phosphorescence.

It is to this part of the question that the researches of Herr Zacharias were particularly directed. It did not suffice for him, through reasoning alone, to extend to the permanent magnet a hypothesis that was justified by experiment for the electro-magnet only. He endeavored to prove the accuracy of the generality of his suppositions, and in this he thinks that he has succeeded.

The complete similarity in the magnetic curves of the two magnets did not permit of concluding that the least dissimilarity existed between the phenomena. Herr Zacharias did not dream of this for an instant. He doubtless thought that upon magnetizing a piece of steel we abolish a part of the ether in the superficial layers of the metal, and thus produce a difference of pressure. But how is such a difference maintained?

New facts being gradually added to old ones, and observations succeeding observations, Herr Zacharias discovered a special form of magnet, of which, up to the present, he has offered no description, but which, it appears, has given him definitive proof that magnetism is a manifestation of molecular motion.

The sole difference that exists between the electro- and the permanent magnet is, that in the former the motion of the ether is evoked artificially, while in the latter it is maintained through the oscillations of the molecules of matter combined with the ethereal displacement.

If we submit a freely suspended magnetized needle or an astatic system to the action of luminous or calorific radiations, we shall observe no displacement of the object in question. Such is not the case, however, with the magnet discovered by Herr Zacharias. This displaces itself in one direction or the other through the effect of the radiation, according to circumstances. It is upon this interesting property that the German scientist has based his theories to the support of which he has subsequently advanced complementary experimental arguments.

The possession of this particular magnet has permitted him greatly to extend a study of the sensitiveness of a large number of bodies to radiant energy. All bodies in general are capable of displacing themselves under the effect of calorific or luminous rays; but this property is much less marked than it is with the Zacharias magnet, and is witnessed only under absolutely particular circumstances. So, despite the account given by Herr Zacharias of his experiments, his observations have been disputed.

Herren Uppenborn and Baumann renewed the experiments of their fellow countryman, but reached no results of the same kind. They explain the phenomena made known by Herr Zacharias as due to a want of care in the experiments. Have they been too hasty to condemn an adversary? That is what the latter claims.

A large number of substances were submitted to the test. These were suspended from light threads of different substances in protective tubes of glass. With some of them the experiments were reproduced in a vacuum. In order to avoid every possibility of error due to the torsion of the suspension thread through humidity, etc., axes of steel pivoting upon jewels were adapted to some of the magnets. In all cases, the results obtained were in accord with each other. So that, although they are far from being completed, these long and laborious researches prove at the least, that the hypothesis advanced by Herr Zacharias can alone explain the phenomena observed by him. It is certain, declares the experimenter, that it is impossible to seek for the cause of the facts observed in the convection of the air, in calorific currents, in the heating of the substances employed, etc.

Another very interesting series of researches was made by means of polished metallic balls of various natures. The object of using these balls was to prevent any effect due to the action of the heat upon the air contained in any unevennesses of the surface.

One of the most remarkable of these experiments was the following: A steel ball of a special nature, and about one inch in diameter, was suspended from a thread about seven feet in length. Both the ball and thread were protected against the agitation of the surrounding air by a sheath of paper, glass, or sheet copper about three one-thousandths of an inch in thickness. Separated from the first by a partition, there revolved, at the rate of from 100 to 200 revolutions a minute, a copper sphere 2.36 inches in diameter, suspended between two metallic points in the interior of a metallic ring. The rotary motion of this second ball had the effect of causing the first to revolve in one direction or the other according as the copper sphere was turned to the left or right. The steel ball tended to follow the other in all its motions. It stopped when the rotation of the second ceased, and its angular deviation was abruptly reversed when the direction of the impulse given to the directing ball of copper was changed.

Some of the other experiments were no less singular. Metallic balls were displaced under the effect alone of the heat radiated by a lighted cigar, by the hand, or by the tip of a finger. The Zacharias magnet, or a glass rod rubbed a few times, produced a more or less marked motion of disks of aluminium, magnesium, etc. Certain substances showed a pronounced tendency to revolve in one direction rather than in the other. There were some of which the direction of motion was capable of being modified at will. It is possible to cause the displacement of certain bodies by means of an insulated plate of copper, heated, for example. A disk of mica revolves very rapidly. The phenomena under consideration may be easily observed with the balls employed for bicycle or automobile bearings. Selenium and magnesium, which up to the present have been considered as non-magnetic, are likewise set in motion by a horseshoe magnet. Magnesium shows itself to be particularly sensitive when it is suspended from a thread in a vacuum. In certain cases, however, and especially when narrow tubes are operated with, there occur phenomena of electric charge that prevent the magnetic efforts from being observed. These latter manifest themselves then only after the bodies present have been discharged of their electricity.

Such are some of the experiments that have been performed by Herr Zacharias, who considers them as having caused science to make a genuine advance, even admitting that they do not constitute the last word to be said in the matter. The application of calculation to the present ideas will be able to lead to greater improvements still.

A mathematician compares the electric current to an uninterrupted succession of infinitely small sparks, while the molecules of conducting bodies are supposed to oscillate in an insulating medium—intermolecular ether. Between the neighboring molecules, differences of potential exist, and it is to such differences of potential that are due the sparks that collectively constitute the current, and that act upon the surrounding space like so many centers of Hertzian waves. The totality of the sparks behaves in the same way. The effects are governed by the law of Poynting. This hypothesis, extended to all electric phenomena, gives a mechanical explanation of electric and electro-magnetic manifestations, which are considered as particular cases of the disruptive discharge pointed out by Hertz, and which are induced in the dielectric by the discharges of currents. . . .

Another question of magnetism with which Herr Zacharias has occupied himself is the application of the electro-magnet to therapeutics, and with this object in view, he has endeavored to ascertain the form best adapted for use in medicine. Experiments have been made with electro-magnets of diverse forms, as well as with different intensities of continuous or alternating current, varying between 2 and 40 amperes, with a tension of from 110 to 120 volts.

As a general rule, the magnetic curves of electro-magnets excited by the alternating current are of slight extent, while with currents of 40 amperes the field does not occupy more than from 12x20 to 16x18 inches, the potential being 120 volts.

The results are better with the continuous current, which permits of obtaining visible fields of from 24x36 to 36x56 inches.

In order to facilitate the study of the magnetic curves Herr Zacharias produces it upon a sheet of stiff cardboard. The principal lines are reinforced with a pencil. It is thus possible also to obtain fields drawn by hand or reproduced by photography.

The largest magnetic field was produced by a Trüb horseshoe electro-magnet of the continuous-current type.

A glance cast at the reproduction of the field produced by this magnet when it is in an inoperative condition in a horizontal plane, will suffice to convince the observer of the magnetic power of this instrument. It is much more energetic, especially, than that employed in certain apparatus in which only one of the poles is utilized for medicinal purposes, so in mounting it, as is usually done, with an electric motor, making from 1,500 to 2,000 revolutions a minute, there is obtained a continuous rotary field of an exceedingly intense effect.

The magnetic curve is very characteristic, and it is easy to observe the modifications caused therein by the introduction of a piece of iron. In the following case it assumes a peculiar aspect: There is produced in the first place an image of the field of the magnet in an inoperative state in a horizontal plane, and then the instrument is set in motion at the approximate rate of 1,500 revolutions a minute. The particles of iron filings in the vicinity of the magnet displace themselves and intermingle, while the most distant lines remain unaltered in consequence of the too great friction of the metal upon the cardboard; and, besides, in the space nearest the polarized pieces, the lightest particles move over the cardboard in the direction of the pre-existing lines of force.

Herr Zacharias is at present occupied in seeking an explanation of the few new phenomena that he has observed in the course of his experiments, and is also actively pursuing his studies upon magnetism.

CONTEMPORARY ELECTRICAL SCIENCE.*

THE SOLAR CONSTANT.—A. Hansky has determined the constant of the sun's radiation in the course of some actinometric measurements made on the summit of Mont Blanc under particularly favorable conditions. The solar constant has been given values which show a steady increase at each successive observation. Thus Pouillet gave it as 1.763, Violle as 2.54, Crova as 2.83, Langley as 3.068 and Angström as 4.0. The author is convinced that the last value is considerably too high. He makes out that it lies between 3 and 3.5 calories, but that it is certainly higher than Langley's value.—A. Hansky, Comptes Rendus, February 13, 1905.

GRAVITATION.—A. Föppl has endeavored to discover any effect that rapid motion may have upon the transmission of gravitational attraction. For this purpose he suspended a weight within a few millimeters of a flywheel 50 centimeters in diameter, which weighed ½ hundredweight and could be given a tangential velocity of 60 meters per second. The flywheel was cased in tinned iron in order to prevent the effect of air vibrations and air currents. The author obtained a deflection, apparently due to increased attraction, and amounting to a few thousandths of a millimeter. He is, however, convinced that this result is due to observational errors, though he is unable to account for them, especially since the deflection does not increase when the vibration of the supports increases. He repeated the experiment with a torsion balance inclosed in a cardboard box, and then obtained no perceptible deflection. He points out, however, that his experimental means were somewhat inadequate.—A. Föppl, Physikalische Zeitschrift, February 15, 1905.

DIMENSIONS OF ELECTRIC QUANTITY.—By a curious mathematical artifice, V. Fischer endeavors to make out a case for putting the dimensions of electric quantity simply equal to those of mass—viz., M. Starting from the fact that the mass required to exert upon 1 gramme at a distance of 1 centimeter a gravitational attraction of 1 dyne is 15 million grammes, he brings this number into relation with the values found for the ratio e/m, which range from 11 million to 19 million. He puts the Newtonian law of gravitation into the form

$$P = \frac{1}{\varepsilon}\frac{m' m''}{r^2}$$

and Coulomb's law of electrostatic attraction into the form

$$P = \frac{1}{\varepsilon}\frac{e' e''}{r^2}.$$

Putting $1/\varepsilon = 1$ as in the electrostatic system, he gets $e/m = 1.5 \times 10^7$, which resembles the value found for the same ratio in the electromagnetic system of units. He defines the "electric gramme" as 15 million ordinary grammes.—V. Fischer, Physikalische Zeitschrift, February 15, 1905.

SECONDARY CATHODE RAYS.—That the impact of electrons upon atoms tends to ionize those atoms by the detachment of electrons from them has been shown by a number of observers, among whom Stark has perhaps done most to elaborate in detail the theory of this action. P. Lenard has collected some further interesting material, in the discussion of which he shows that it is possible to detach the effects produced by primary cathode rays from those produced by the secondary ones to which they give rise. He accomplishes this by sending the primary rays through a diaphragm, behind which a phosphorescent screen is mounted parallel to the path of the rays, but out of their direct reach. When this phosphorescent screen is charged to several thousand volts, the rays are drawn aside, producing on the screen various patches, whose aspect varies with the voltage and the pressure of the gas. With a suitable distribution of the voltages it is possible to separate the direct rays from the slower secondary rays, which appear as a diffuse and much-deflected patch. The manner in which these rays are produced shows some striking analogies to ultra-violet light. This, like cathode rays, produces a conductivity in gases due to the liberation of electrons. It also discharges negatively electrified bodies, and the author shows in this connection that cathode rays impinging upon solids also cause them to emit secondary cathode rays of very low velocity. He believes that the discharging of solids and the conductivity of gases are equally due to these very slowly moving electrons. Like all other effects of cathode rays upon matter, the production of secondary rays is independent of the state of aggregation of the material. It is also independent of the orientation of the surfaces impinged upon. The so-called "reflection" of cathode rays is a complex phenomenon in which the field due to the reflecting body, the electric waves proceeding from it, and the secondary cathode rays each play an important part. The author's main object was to single out the effects due to the last of these elements.—P. Lenard, Annalen der Physik, No. 13, 1904.

TANTALUM.

PROBABLY all that most readers could tell offhand about tantalum is that it is used as the luciferous filament in the new Siemens & Halske incandescent electric lamp; that it used to be described in the book in that threatening footnote of close black type; and that it was unjustly named by its exasperated discoverer in allusion to some hazy mythological scamp, who was justly condemned to an eternity of teasing. All of this is true, and it is all an illustration of the close interdependence and mutual stimulation of theoretical and practical chemistry. Tantalum can really tell a connected and fascinating story. It is a rare element in the sense that it is rare to find a chemist who can analyze its compounds quickly and accurately. The peculiarly "tantalizing" quality it has is illustrated by its somewhat whimsical solubilities. Its oxide, Ta_2O_5, and the corresponding acid, H_3TaO_4, are ambiguous in most unique and original and changeable rôles. With tantalum is associated columbium (the element that the Germans tried to name niobium), and both of these have oxides and acids that are precipitated by dilute acids, dissolved by strong acids and alkali, and that filter according to no law but one of changeable caprice. But the demands of invention have called this tantalum from the pigeon-hole of theoretical chemistry to the front row of usefulness.

Tantalum is a gray, hard, heavy metal, with a specific gravity of 16.8 when pure and rolled; which means that it is heavier than any common metal except gold and platinum, being much heavier than silver, lead, or mercury. The only acid which will attack it is hydro-

* Compiled by E. E. Fournier d'Albe in the Electrician.

fluoric, and then only when heated. It unites with hydrogen and nitrogen, even at low red heat, forming brittle metalloidal compounds. It also unites with carbon, to form carbides. The pure metal is as hard as mild steel, and a little darker than platinum. The atomic weight of tantalum is 18.3, it being the highest homologue of the vanadium-columbium-didimium group. It is in the fourth long-series of the Periodic Sequence, being in the second space after ytterbium, and immediately before tungsten. It is obtained in the metallic state by reduction of the double fluoride, K_2TaF_7, by metallic sodium, and the resulting metal is re-purified by heating in a vacuum. The metal can also be obtained by igniting the brown tetroxide of tantalum as a filament in a vacuum; but the former method is the better. We may expect to see improvement in its metallurgy.—The Engineering and Mining Journal.

ELECTRICAL NOTES.

The Stubai Valley Railway in the Tyrol, near Innsbruck, will long be noted as the first line to be operated commercially by single-phase motors. The cars have four 40-horse-power Winter-Eichberg motors connected in two groups in parallel, and draw trailers. There are a few freight cars among the rolling stock. The line is about 12 miles long, and has some long and stiff grades. The frequency is 42 cycles, which is rather interesting in view of the American prejudice against a frequency above 25 cycles. The current is transmitted at 10,000 volts, and is reduced to 2,500 volts for the trolley wire. The road has been in operation about seven months. The consumption of energy measured at the feeding point, so as to include the losses in the secondary network and trolley wire, has been about 70 watt-hours per ton-kilometer. The mechanical power was calculated from measurements of the train resistance to be 48 watt-hours per ton-kilometer; the efficiency of the system was, therefore, about 68 per cent. It will be interesting to observe if the success of this installation, and the operation of the Indianapolis-Cincinnati line in the United States will prove the long-needed incentive for the introduction of the single-phase motor on the many lines for which electrical experts assert that it is pre-eminently fitted.—Eng. Record.

During the twelve years from 1890 to 1902 the total single-track mileage for street and electric railways increased from 8,123 to 22,577. This increase was due partly to the establishment of new railways, but principally to the extension of the lines already existing. The mileage of the electric lines increased from 1,262 to 21,907, while there was a decrease for the lines operated by other motive power, the decrease being from 488 to 241 miles for cable lines, from 711 to 170 miles for steam lines, and from 5,662 to 259 miles for lines using animals for their motive power. In proportion to its area, Massachusetts has much more electric railway mileage than any other State. The average length of track per operating company increased from 10.56 miles to 27.63 miles during the same period. The increase in mileage was accompanied by corresponding increases as follows: Cost of construction and equipment, from $389,357,289 to $2,167,634,077, or 456.7 per cent; operating expenditures, from $62,011,185 to $142,312,597, or 129.5 per cent; number of passenger cars, from 32,505 to 60,290, or 85.5 per cent; number of fare passengers carried, from 2,023,010,202 to 4,774,211,904, or 136 per cent; and number of employes, from 70,764 to 140,769, or 98.9 per cent.

The experiments that are being carried out by the Northeastern Railroad of Great Britain with electric locomotives for the handling of freight traffic are being followed with great interest. These locomotives are of a powerful type to cope with the heavy tonnage, and the hilly nature of the roads, the gradient connecting the freight yard to the trunk road being 1 in 27. For the purposes of the experiment the railroad has acquired two locomotives weighing 57 tons, and each equipped with motors of 800 horse-power, and capable of hauling a load of 150 tons on the heaviest gradient. Each locomotive measures 37 feet 6 inches in length, and is mounted on two four-wheel bogies, each axle being motor-driven. The locomotive is fitted with four G. E. .55 motors geared to 36-inch wheels at a ratio of 3.29 to 1. The British Thomson-Houston Company's standard system of train control, similar to that on the passenger stock, is used, but without the automatic acceleration feature. Two controllers are provided, one at each end of the center cab. The contactors, resistances, and reversers are fastened to the floor inside the sloping ends. The usual electrical couplings are attached to the headstocks, by means of which both locomotives can be operated together from either as desired. The overhead collector is of the pantograph type, and is specially designed to meet the requirements of the changing height of the supply cable, which varies from 15 feet maximum to 13 feet 6 inches under bridges. Provision is made for lowering the collector from the interior of the cab when necessary by means of a hand-wheel geared to the collector.

A new fusible electric cut-out has been invented by an electrical engineer of Ireland, the characteristic of which is the prevention of any electric arc by the cut-out action. The device is very simple, and can be adapted to any existing type of electric cut-outs and switches, while it also enables burnt-out fuse wire to be easily replaced and the current re-established. There is a porcelain case fitted with terminals.. Inside this casing there is a sliding plug which has a plate, and attached at one end to a spring of conducting material by means of a screw. The spring is drawn through a recess in the end wall of the casing, and screwed to the terminal plate. The other end of the plug is connected by means of a screw with a fuse wire, which is drawn through recesses in the plug and end wall of the casing respectively, and then bound to the terminal plate by means of a screw. There is a bridge piece with a notch, in which the central portion of the fuse wire rests. Under normal conditions the current passes from one terminal of the cut-out to the other by the fuse wire, plate, and spring. When the potential of the current becomes high, the fuse wire breaks down at the point where it is stretched over the bridge piece. The spring being under tension immediately draws back the plug in the casing, thereby separating the ends of the fuse, and precluding the possibility of the formation of an arc. The cover is also provided with two orifices, to allow of the escape of air from the casing, and to permit air to enter when the fuse burns out. An inwardly-closing flap valve is fitted to the opening.

ENGINEERING NOTES.

Considerable competition has arisen between the steam roads and the electric interurban lines. While the steam roads have the advantage of greater speed, the frequent service, convenient stops, and low fares of the electric roads have, in many instances, seriously affected the local traffic of steam railways. Statistics show that in 1902 the street and electric lines of the United States carried more than seven times as many fare passengers as the steam railways. Such a comparison, however, means little, since steam railway journeys are, as a rule, much longer than those on street railways. In 1902 the average distance traveled by passengers on the steam roads was 30.3 miles. No definite average can be given for the distances traveled by passengers on the street lines, since no records have been kept by the street railway companies relative to this point. The receipts from passengers were $392,963,248 for steam railways, and $233,821,548 for street railways. In 1902 the passenger earnings of the street railways were 94.5 per cent of the total receipts; the remainder of the revenue was derived from the sale of electric current, from freight, mail, and express service, and from advertising and other miscellaneous sources.

A novel oil engine primarily designed for operation in a rugged country with practically no properly constructed roads or tracks has been devised. It possesses several interesting features, one of the most noticeable of which is that the engine is fitted with reversing gear, rendering it applicable to those purposes in which changes of direction of working are required. The cylinder of the engine is carried upon a steel truck built up of steel girders plated over the top, to which it is rigidly fixed and stayed. To the underside of these girders axle plates are riveted and carry the axles, which are bolted thereto. The space within this truck is occupied by an independent water tank, which has a capacity of 50 gallons. The cooling water is circulated by means of a pump, and after the passage of the water through the cylinder jacket, it is delivered into the water cooler. As it descends through the latter, hot water, which is of a temperature of about 140 deg. F., comes into contact with a current of air which is passing upward, and this action reduces the temperature of the water to 95 deg. F. One of the most interesting features of this engine is the vaporizing arrangements. These have been considerably improved; and whereas formerly it was only possible to obtain compressions of about 45 pounds or 50 pounds to the square inch, it is now possible to obtain much higher pressures without any of the troubles formerly experienced in connection with preignition of the charges when the compression was raised above the foregoing maximum. This problem has been solved to a great extent by the injection of water along with the oil into the combustion chamber and vaporizer. The water is not strictly forced into the combustion chamber, but is drawn into the cylinder by suction from the water jacket. There is a special valve fitted within the combustion chamber, and as the piston makes its outstroke, the action draws water through this valve into the chamber simultaneously with the suction charge of the explosive mixture from the vaporizer. The water is then vaporized in turn by the combined heat of the chamber and the compression. By this principle it is now possible to obtain compressions approximating 70 pounds and 80 pounds per square inch, and at the same time a reduction in the quantity of oil required to produce a certain horse-power is effected. In some cases this reduction amounts to as much as 25 per cent. In the actual tests carried out with this engine, which is of 250 horse-power, the fuel consumption amounted to 0.64 pint of fuel per brake horse-power hour. By means of this high compression, moreover, oils of a higher flash point than hitherto used for such engines can be employed with the same degree of efficiency, which in view of their lower price and attendant economy in running the engine constitute an important advantage. Beside the cylinder is placed the reversing gear. This attachment is incorporated, as this engine is primarily built for oil-well drilling, where it is required to drive the boring tool in different directions for boring and withdrawing. The gear is constructed upon the clutch principle. There are two of these clutches, connected by a well crank and controlled by a handwheel. The various movements of starting, stopping, and reversing can be easily and quickly carried out. The clutches bring into operation a series of gears and pinions driving in either direction as required. The attachmen gear is quick in action and free from shock, thereby rendering it peculiarly adapted to sudden changes and smooth regular work, such as is required in oil-well boring.

TRADE NOTES AND RECIPES.

The Regeneration of Old Rubber.—For the purpose of reclaiming old vulcanized caoutchouc or other forms of rubber, it is found advisable, after first cutting it up into bits, to boil it with constant stirring in a properly constructed vacuum pan at a temperature of about 100 deg. C. with five times its weight of commercial phenol until the material shall have been completely dissolved. Care must be had to provide the boiling apparatus with a reflux cooler. Thus arranged, the greater part of the phenol will be distilled off and reclaimed, and from the remaining solution the caoutchouc may be precipitated and thoroughly washed out by the addition of alcohol, soda lye, or any other convenient solvent for the residual phenol.

As far as the sulphur contained in the vulcanized rubber is concerned, part of it goes off in the shape of gaseous compounds during the boiling process, and whatever remains may be precipitated out of the solution by the addition of a small quantity of lead acetate. Should the sulphur, however, not be precipitated after this fashion directly following the distillation of the phenol, then it may be precipitated together with the rubber, whereupon the resultant mixture may be immediately revulcanized. In place of phenol, creosote may be employed, or for that matter any other substance that possesses the properties of dissolving both the rubber and the sulphur.—Erfindungen and Erfahrungen.

Leather Making by Means of Combinations of Tin.—In this process the multifarious compounds of common tin are advantageously used for the tanning of leather, by causing the colloidal salts of tin to deposit between and in the fibers of the skin. Leather cured in this manner is adapted for the greatest variety of uses, except of course for the parts of boots or shoes (uppers). For the tanning liquor proper use is made of pure solutions of the salts of tin, such for instance as ordinary tin salt, tin chloride, pink salt, tin oxalate, sodium stannate, tin sebates, and similar combinations.

The hides to be cured should first be treated with common salt before steeping in the tin bath; for instance, after the customary preparatory operations, the hide should be steeped for eight hours in a solution of common salt, and thereafter laid in a solution of tin in the proportion of 100 grammes of water to 1 gramme of tin salt, to which may be added a trace of hydrochloric acid. After lying two hours in this, the hide is removed and carefully washed in clear water, after which it is again replaced in the tin bath. Allowed to steep for another two hours, it is finally removed, well washed, and dried. A slight stretching of the shrunken skin is sufficient to provide the grain with a fine gloss. The ultimate product is a soft, pliable, and delicate-feeling leather.—Chemiker Zeitung.

The Manufacture of the Butterini di Sorrento.—The Butterini di Sorrento form in Southern Italy, particularly in Sorrento and the country round about Naples, a very popular means of sustenance, consisting of butter and cheese, which in this shape may be preserved in an edible condition for several months even in warm climates. The newly-churned butter is made up in rolls weighing from 70 to 80 grammes and allowed to harden in ice-water. About 250 grammes of ordinary cheese made from cow's milk is now taken and shaped into a form somewhat resembling a brimless hat; this is first softened in boiling water, and when sufficiently pliable the roll of hard butter is snugly imbedded into it, and it is then sealed, assuming the shape of a gourd, whereupon the combined butter and cheese is again immersed in ice-water to cool and harden. After some hours of this chilling bath it is treated to a bath of salt water, in which it remains for at least ten hours, being finally hung up in the open air, there to remain till wanted for use. These butterini will keep in Southern Italy about three months in winter and one month in summer, and they cost about 29 cents per pound.

According to investigations made by Neufeld, the cheese used was found to be a hard, close-grained variety containing about 30 per cent of fat; it is rather tough, and of a light color, possessing an even character and without holes or pores. Its taste resembles very closely the Dutch cheese made in some of the provinces of northwestern Germany. The thickness of the covering of cheese outside the butter varies from 9 to 16 millimeters, and the inclosed butter roll has a length of about 7 millimeters upon a diameter of about 5 millimeters, being in close contact with the cheese at all points.

The butter naturally assumes a cheesy taste, and reminds one strongly of cheap cooking butter. Its composition is normal. After being suspended thus in the open air, one of these butterini was found to have lost 30 grammes in weight, which fell solely upon the cheese envelope, since its thickness was then only from 6.5 millimeters to 10 millimeters, and the water contents had sunk from 30 per cent to 15 per cent.

The appearance of the butter had scarcely changed other than that the exterior film which lay next the cheese had taken on a deeper yellow shade. Neither the taste nor the odor had suffered any alteration, nor had it become rancid or otherwise spoiled. There was moreover neither trace of fungus formations nor noticeable discoloration. Tests demonstrated approximately the same values as those possessed by the newly-made butterini, except that the acid number had

risen from 5 deg. to 10 deg. As for the cheese, it also did not show any deterioration in its values. Tests for bacteria furnished very favorable results. Upon the whole, this method presents a most excellent means of preserving without ice a very delicate substance.—Zeitschrift für Untersüchung der Nahrung und Genussmittel.

SELECTED FORMULÆ.

To Fasten Brass upon Glass.—Boil together 1 part of caustic soda, 3 parts of rosin, 3 parts of gypsum, and 5 parts of water. The cement made in this way hardens in about half an hour, hence it must be applied quickly. During the preparation it should be stirred constantly. Remember that all the ingredients used must be in a finely-powdered state.—Metallarbeiter.

A Good Lubricant for Wooden Cogwheels.—This consists of 30 parts by weight of tallow, 20 parts of palm oil, 10 parts of good train oil, and 20 parts of graphite. Over a mild heat the tallow and oils are melted together, and into them the finest pulverized graphite is stirred until a most thorough mixture is obtained. In many cases tallow alone is used, or a lubricant made of graphite. The teeth of the wooden cogwheels will remain serviceable much longer if to the ordinary tallow or graphite lubricant one-tenth part by weight of powdered glass be added to them.—Praktischer Wegweiser.

Soup Preserve.—The recipe given by the French War Department for the preparation of a soup from bean flour reads as follows:

White bean flour	55 kilos.
Lard	7 kilos.
Pork	40 kilos.
Salt	5 kilos.
Ground pepper	0.4 kilos.
Finely cut onions	6 kilos.

These 113.4 kilos are boiled down to 100 kilos.

The pork should be medium fat; the lean and the fat parts are separated, and the fat parts coarsely cut up. Next the latter are well browned in a kettle and the onions mixed in. After the lard, salt, and pepper have been added, the bean flour is stirred in in small portions. The mass is filled in cans holding 170 grammes of the mass and 30 grammes of the finely chopped lean pork which constitutes one portion. Then close the cans and sterilize them for one-half hour at 117 deg. C. (242½ deg. F.).—Konserven Zeitung.

For the Removing of Rust from Instruments.—The following receipt is highly recommended by Kraft und Licht: Lay the instrument over night in a saturated solution of chloride of tin. The spots of rust disappear by reduction. After their removal rinse the instruments well in clear water, and immerse them in a hot suds made with soda soap, and dry well. Though not absolutely necessary, yet it is advisable to give them another cleansing with pure alcohol and polishing powder. Another simple means for the removal of rust is common petroleum. To prevent steel instruments from rusting, still another method is advised, viz., to grease them with paraffine oil. Since, however, this is rather an irksome job with complicated instruments, and with needles scarcely possible to do properly and effectively, too much paraffine oil being very easily applied, which means much labor to remove when the needles are wanted for use, we recommend the following procedure: Make up a solution of 1 part of paraffine oil in 200 parts of benzine. In this dip the instruments, which have become thoroughly dry by lying in warm air. Work their movable parts, if they are forceps or scissors, when immersed, to allow the fluid to penetrate every crevice. Now place them upon a tray in a warm place, to allow the benzine to evaporate. Needles are simply thrown into the solution, allowed to remain a few minutes, the liquid drained off, and the needles left to dry by the natural volatilization of the residual benzine.

Production of Fruit Vinegars.—Strawberry Vinegar.—Crush 1 kilo of ripe strawberries into a mush, fill in to a bottle and pour 15 kilos of good pure vinegar on it. Place the bottle, which must be closed with a tight cork, in a warm spot and shake from time to time. After the mixture has stood for six to eight days, the vinegar is filtered and kept in filled-up bottles in a cool place.

Raspberry Vinegar.—Crush 1 kilo of ripe raspberries, fill into a bottle and pour 15 kilos of vinegar of good quality over it, treating it like the strawberry vinegar.

Lemon Vinegar.—Peel 12 lemons, squeeze out the juice and allow to clarify in a vessel. Crush the peels and pour 15 kilos of good vinegar on the pulp obtained. Mix the clarified lemon juice to it, filter the whole and keep in well closed bottles.

Orange Vinegar.—Peel two oranges, squeeze out the juice, which is filled in a bottle and allowed to settle. Crush the peels and pour 15 kilos of good vinegar on them in a bottle, add the clear juice and filter. The orange vinegar which is now ready should be preserved in well closed bottles.

Huckleberry Vinegar.—Crush 1 kilo of huckleberries, pour 15 kilos of good vinegar, letting it stand for six to eight days, during which time the bottle should be shaken frequently. Next filter the vinegar and keep in a cool place.

Herb Vinegar.—Fresh sweet marjoram leaves, 250 grammes; fresh thyme leaves, 250 grammes; sardels (cut up), 70 grammes; curly mint, 70 grammes; basil herbs, 50 grammes; shalots, 30 grammes. Cut everything up fine, put in a bottle, pour 15 kilos of good vinegar over it and filter.—Neueste Erfindungen und Erfahrungen.

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